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DEVELOPMENT OF A PREDICTIVE REGRESSION MODEL FOR ESTIMATING CONSTRUCTION PERFORMANCE OF ETHIOPIAN FEDERAL ROAD PROJECTS

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M.Sc. THESIS

BY

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A thesis submitted to the school of Research and Graduate Studies of Bahir Dar Institute of Technology, BDU in partial fulfillment of the requirements for the degree of master of science in construction technology and management.

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Approval of thesis for defense result

I hereby confirm that the changes required by the examiners have been carried out and incorporated in the final thesis.

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As members of the board of examiners, we examined this thesis entitled "Development of a Predictive Regression Model for Estimating Construction Performance of Ethiopian Federal Road Projects" by Melaku Adane. We hereby certify that the thesis is accepted for fulfilling the requirements for the award of the degree of Masters of Science in "Construction Technology and Management".

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I, the undersigned, declare that the thesis comprises my own work. In compliance with internationally accepted practices, I have acknowledged and refereed all materials used in this work. I understand that non-adherence to the principles of academic honesty and integrity, misrepresentation/ fabrication of any idea/data/fact/source will constitute sufficient ground for disciplinary action by the University and can also evoke penal action from the sources which have not been properly cited or acknowledged.

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ABSTRACT

Construction industry is complex in its nature since it involves large number of stakeholders. In Ethiopia the number of road projects is increasing from time to time due to the emphasis given to the sector. However, it has become difficult to complete projects in the allocated cost, time and quality. The main objective of this research was to develop forecasting model that helps construction stakeholders to precisely predict construction performance of a road construction projects by using multi-variate regression technique. Detailed literature review was done and 61 factors that had tangible impact on construction performance were listed and grouped in 7 groups namely: Cost, Time, Quality, Productivity, Client Satisfaction, Health and safety and Innovation and Learning. A questionnaire survey was conducted on ongoing Federal road construction projects in the Central Region. Total population sampling technique was used to collect the data since the population to be studied is limited. Based on the result of the survey, from the 61 factors 9 were selected as most significant factors based on their RII value. These nine factors were then subjected to Principal component analysis method in order to reduce their number, and four factors (Delay in payments, Cash flow Problem, Resource Availability and Sequencing Practice according to schedule) were factored out for the model formulation process. From the collected data 80% were used in the training set or model formulation. Multi-Variate regression was done using SPSS to generate the forecasting model. An Enter selection method was used in developing the model, which resulted in R^2 value of 84.9% which indicates a good predicting capability of the model. Finally, the developed model was validated by using the remaining 20% of collected data and resulted in small amount of mean average percentage error (MAPE=2.98%). The developed predicting model helps construction stakeholders mainly contractors involving in road constructions in the initial and construction stages by providing them a predicting formula. And also Contractors are advised to give serious attention for the factors listed out in this paper as they have a great impact in affecting construction performance.

Keywords: *Construction performance, Model formulation, Multi-variate regression*

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Acronyms

ANNs	Artificial Neural Networks
ANoVA	Analysis of Variance
APE	Absolute Percentage Error
CFP	Cash flow Problem
CP	Construction Performance
DP	Delay in Payments
GDP	Gross Domestic Product
KMO	Kaiser-Meyer Olkin
MAPE	Mean Absolute Percentage Error
MLR	Multiple Linear Regression
Ms. Excel	Microsoft Excel
PCA	Principal Component Analysis
PSNP	Productive safety net projects
RA	Resource Availability
RII	Relative Importance Index
SD-DES	System Dynamics - Discrete Event Simulation
SEM	Structural Equation Model
Sig.	Significance
SP	Sequencing Practice according to schedule
SPSS	Statistical Package for Social Science
VIF	Variance Inflation Factor

1. Introduction

1.1. General Introduction

The construction industry is an enormously important part of any countries economy. Economic growth depends on the physical infrastructure that is delivered by the construction industry and its key participants. The construction industry is complex in its nature because it comprises large numbers of parties as owners (clients), contractors, consultants, stakeholders', shareholders and regulators. The performance of the construction industry is affected by national economies (Shaban, 2008).

Construction sector plays a leading role in economic growth for countries all around the world. The output of the construction industry constitutes one-half of the gross capital and is 3 to 8% of the Gross Domestic Product (GDP) in most countries (Thomas & Sudhakumar, 2014).

With such a high contribution, the construction industry has a major influence on the economic growth of the country; conversely it is highly dependent on the state of the economy to realize its potential. An inefficient and ineffective performance of the construction industry on the other hand will adversely affect all other sectors of the economy (Tadesse, 2009).

The performance of construction industry is one of the major development constraints in developing countries since their development highly depends on the growth of their physical infrastructures (Wubishet, 2004). As a matter of this fact, developing countries allocate a considerable amount of their scarce financial resources towards the development of their infrastructure needs. However, most of these infrastructure projects in developing countries encounter considerable low performance in terms of time, cost and quality etc. (Tadesse, 2009).

Ogunlana (2004) and Wubishet (2004) described that many of these performance related problems are recurrent and serious. Because of this, many researchers in developing as well as developed countries undertake several studies on specific aspects of performance related problems such as time, cost and quality in many countries.

1.2. Background of the Study

Transport infrastructure is generally considered as an essential element for economic and social development as it provides the links required to make commodity or markets function. The development of any country economically vital sectors such as agriculture, industry, tourism etc. is directly dependent on the existence of a working transport infrastructure system.

In the context of Ethiopia's geography, pattern of settlement and economic activity, transport plays a vital role in facilitating economic development as 95% of the movement of people, and goods is still carried out by road transport. In particular, it is road transport that provides the means for the movement of peoples and agricultural products from rural areas to urban areas and movement of industrial goods, modern agricultural inputs and peoples from urban areas to rural areas. Road transport also provides a means for the utilization of land and natural resources, improved agricultural production and marketing, access to social services, and opportunities for sustainable growth (ERA, 2013).

Recognizing the importance of the road transport in supporting social and economic growth and its role as a catalyst to meet poverty reduction targets, the Government of Ethiopia has placed increased emphasis on improvement of the quality and size of road infrastructure in the country. To address constraints in the road sector, mainly low road coverage and poor condition of the road network the Government formulated the Road Sector Development Program (RSDP) in 1997. Since the start of the RSDP, a number of road projects are under construction and a lot more are expected to be commenced in the coming years (ERA, 2013).

The Ethiopian Roads Authority as a Government implementing agency has been administering huge budget every year which is allocated to the road infrastructure development, however, this government investment of huge capital to the road sector is not free from challenges. The review of the implementation of the Road Sector Development Program (RSDP) shows that road projects in Ethiopia encounters a number of challenges (Zerfu, 2009).

Therefore, making improvement in the performance of road sector of the country will have a significant impact on economic and social sectors as well. With this objective in mind this research will assess the critical factors which are affecting the Performance of projects in: time, cost, quality, client satisfaction as well as other undesirable causes that hinder road construction projects success. Hence, the major output of this research work will be to develop a predictive model to predict the performance of any given road project. In order to undertake the research work, Ethiopian Roads Authority (ERA), which is in charge of the administration of the road construction projects under the federal government supervision, is selected as a case.

1.3. Problem Statement

Ethiopia is one of the fastest growing countries in the world, but poor transportation facilities have become a bottleneck to the growth of agriculture and manufacture in the country thereby affecting economic development. Ethiopian Government has undertaken projects to improve the country’s transport network. From these projects, the construction of Road is very significant. Successful construction of Road plays an important role hence these projects consume a considerable amount of finance. For the past few years, the constructions of Road have developed in Ethiopia therefore proper assessment of their performance is very critical. According to observations, some of the Road projects are progressing far beyond the stipulated time frame, with high cost overrun and with less quality of the work.

Therefore, this thesis will identify the factors affecting the performance of Road construction projects, evaluate and compare Critical Factors which are affecting the Performance of projects in: time, cost, quality, client satisfaction and finally develops a predictive model to predict the performance of any given road project at initiation phase and also during construction.

1.4. Objectives of the Study

1.4.1 General Objective

- The general objective of this research is to develop a model for estimating construction performance by using multivariate regression technique for Road construction projects in Ethiopia.

1.4.2 Specific Objectives

- To identify the performance problems that occurred frequently in Ethiopian Federal Road construction projects
- To identify the key performance indicators in Ethiopian Federal Road construction projects.
- To identify the critical factors that affects the performance of Federal Road construction projects in Ethiopia
- To establish a forecast model for construction performance of road projects based on the most critical factor affecting performance of projects.

1.5. Research Questions

- What are the critical factors that affect the performance of Road construction projects in Ethiopia?
- What are the performance problems that occurred frequently in Ethiopian Federal construction projects?
- What are the main key performance indicators in Ethiopian Federal construction projects?
- Is it possible to forecast performance for road construction projects?

1.6. Scope of the Study

The scope of the study is limited both in range and depth. Accordingly, the study area will be limited to Ongoing Federal Road construction projects in Central Region due to time and finance constraints. Hence, this study will involve client, contractors and consultants only that undertakes Federal Road construction projects in the selected Division of Ethiopian Road Authority Projects.

The findings of the research were reviewed in light of previous research findings related to models for forecasting performance of construction projects. The forecasting model was established by using data obtained from ongoing road construction projects in the Central region Division.

1.7. Limitations of the Study

The usefulness of the model developed in this research is limited to the accuracy of the data obtained from the project sites through questionnaire, observation, from their daily log book and interviews with engineers who controls day to day activities of the projects. Prediction is only valid within the range of characteristics of the selected sample data.

The use of the model developed in this research is limited to projects that meet the characteristics of the samples used for model development. i.e. Road construction projects located in central regions.

Delay in payments, Cash flow Problem, Resource Availability and Sequencing Practice according to schedule were the quantitative project scope variables considered in the study. The developed model therefore, do not account for any variation in performance which may arise from other project scope factors.

1.8. Significance of the Study

This study will have the following basic importance. First, it may benefit the different stakeholders involving in construction projects in general and particularly for new Road construction projects related to project performance. Second, it may help owners, contractors and consultants to know the causes and effects of performance problems in construction projects and thirdly this study creates a good knowledge of how a better estimation of construction performance leads to better construction cost and time performances and provides a forecasting model to be used for precisely determining construction performance. And finally, serves as a benchmark for further studies.

2. Literature review

2.1. General Overview

The construction industry is vital for the development of any nation. In many ways, the pace of the economic growth of any nation can be measured by the development of physical infrastructures, such as Roads, Road, rail ways, hydropower stations and bridges (Azeb, 2016).

Construction project development involves numerous parties, various processes, different phases and stages of work and a great deal of input from both the public and private sectors, with the major aim being to bring the project to a successful conclusion (Sullivan, 2013).

As construction is becoming more complex, a more sophisticated approach is necessary to deal with initiating, planning, financing, designing, approving, implementing and completing a project. The common assessment of the success of construction projects is that they are delivered on time, to budget, to technical specification and meet client satisfaction (Azeb, 2016).

However, the criteria for success are in fact much wider, incorporating the performance of the stakeholders, evaluating their contributions and understanding their expectations. A stakeholder is an individual or group, inside or outside the construction project, which has a stake in, or can influence, the construction performance (Sullivan, 2013). Construction projects potentially can have different sets of stakeholders as: client, consultant, contractor, supplier, end-user and the community. Successful construction project performance is achieved, when stakeholders meet their requirements, individually and collectively.

Construction projects involve a great deal of time and capital, so effective construction project management skills are required if the projects are to be completed within the established time line to meet cost limitations and quality requirements. In the construction industry, staying cost effective and competitive means that companies must have core competencies for coordinating the job sites, controlling costs, and managing risk at their construction sites (Sullivan, 2013).

2.1.1. Brief History of Roads in Ethiopia

The earliest modern roads in Ethiopia connecting Addis Ababa to Addis - Alem and Harar to Dire Dawa date back to the first half of the twentieth century (Construction Ahead, 2005). These roads were part of Emperor Menelik's attempt to modernize Ethiopia, however much has not been done until the time of the Italian occupation (1936 – 41). The Italian government invested much capital to expand the very limited infrastructure that then existed. Within one year period, close to 60,000 Italians were working on these projects. The road network even then was designed to radiate outward from Addis Ababa connecting the Italian occupied ports of Massawa and Mogadishu. When the occupation was terminated in 1941, the Italians left behind 7,000 km of roads, of which about half were surfaced with asphalt.

The reinstated Imperial regime was however unable to continue from where the Italians left off as it lacked expertise, adequate funds and equipment. The Government established the Imperial Highway Authority in 1951 with the help of World Bank and technical assistance from the United States Bureau of Public Roads.

In 1951 the total stock of road network was only 6400 km of which 3400 km was asphalt and the remaining 3000 km was gravel road. This entire network was found only in urban areas. When the Imperial regime lost power, the network has reached to 9160 km in 1973. On average, the network has been growing at a rate of 2.05 percent per annum over the period 1951-1973. During the Derg regime, 1974-1991, the stock road increased to 19017 km with a growth rate of 6.2 percent per annum. With the current EPRDF regime, the road network has reached 46812 km in 2009 with an average annual growth rate of 9.35 percent. Over the period 1991 to 2009, 28731 km of new road network was constructed (ERA, 2009). A large space in the country is networked with only a few roads. Though the development is good, more construction is important for connecting the remote areas. Especially, the rural part of Ethiopia is less networked with roads. According to World Bank (2010), only 10 percent of the rural population lives within two kilometers of all-weather roads. Thus, the remaining 90 percent of rural people live at a distance of more than two km from all-weather roads.

The underdevelopment of the road network has its implication for the development of the agricultural sector which is the mainstay of the rural people and the country in general. Visual inspection indicates that a lot has to be done to put a sufficient network in the country. Though there was an increase in the length of roads between 1974 and 1989, it was somewhat constant in the years 1989 to 1991. After, the takeover of EPDRF the government has invested much in construction of asphalt roads. Especially after 2001 there is a significant growth in asphalt road length. However, there is a negative growth in gravel road length. This happened in the recent years like 2003, 2005. One possible cause for the negative growth in gravel roads would be the fact that community roads, which could be considered as part of gravel road, are being constructed with Productive Safety Net Projects (PSNP). This type of road is not counted or included as gravel road for the very reason that it fails to meet the standard set by the Ethiopian Roads Authority (ERA). In addition, either the federal Ethiopian Journal of Economics, Volume XIX, No. 2, October 2010 109 or regional road authorities do not administer this type of road. Another cause may be the fall in expenditure for maintenance and reconstruction, mainly over the period 2003 and 2005 (Ibrahim, 2010).

According to Wubishet (2004), the construction industry in Ethiopia can be viewed by using six distinct periods for its evolution. These distinct periods cover:

1. Pre - 1968: Foreign companies dominated construction industry,
2. 1968 – 1982: Emergence of small scale domestic construction companies,
3. 1982 – 1987: Parastatal Companies dominated construction industry,
4. 1987 – 1991: Fragmentation between design services & construction works,
5. 1991 – 2001: Parastatal Domination legally abolished, and
6. 2001 – Now: Integration Dominated construction industry.

The last period is important for the context of this research. Following the change in government in 1991, market – based economy and decentralization was introduced that resulted in the following, among the list, policy reforms to the construction industry (MEDaC, 1999b cited by Wubishet, 2004):

- Local and foreign private investors were allowed to participate in all areas of construction activities,
- Direct awards to state – owned construction companies were minimized to create competitive environment which was encouraging development.

Construction is second to agriculture in generating employment in Ethiopia (Wubishet, 2004). Capacities in construction, as well as in manufacturing of construction materials, are in a better setting than in other sectors. This is because fairly reasonable institutional and infrastructure bases exist for design and construction in both the public and private sectors.

2.1.2. Capacity of the Construction Industry in Ethiopia

A study by SMEC International (1999); MoWUD (2001); and ERA (2002) all cited by Wubishet (2004) concluded that the general state of the domestic construction industry in Ethiopia is low. The deficiencies were characterized by:

- An inadequate capital base, specifically to construction contractors,
- Old and limited numbers of equipment and their low level of utilization,
- Deficiencies in human resources with regard to technical, managerial, financial and entrepreneurial skills, and
- Very limited experience and participation in private sector for road, bridge and water related construction works and provisions of consulting services.

2.2. Problem of Performance in Construction Industry

The failure of any construction project is mainly related to the problems and failure in performance. Moreover, there are many reasons and factors which attribute to such problem. According to Shaban (2008), the construction industry performance problems in developing economies can be classified in three layers:

- Problems of shortages or inadequacies in industry infrastructure (mainly supply of resources),
- Problems caused by clients and consultants and
- Problems caused by contractor incompetence/inadequacies.

The subject of performance measurement or assessment has become a matter of concern to several countries at different levels of socio-economic development which have realized the need to improve the performance of their construction industry (Nduro & Ahadzie, 2011). Navon (2005) identified in various forms as low productivity, delays, cost overrun, and poor quality and so on. Poor project performance has been noted as the bane of construction industries of several countries, particularly, developing countries.

2.3. Construction Project and Project Performance

Success of construction projects depends mainly on success of performance. Many previous researches had been studied performance of construction projects. Dissanayaka & Kumaraswamy (1999) remarked that one of the principle reasons for the construction industry's poor performance has been attributed to the inappropriateness of the chosen procurement system.

Cheung, Suen, & Cheung (2004) identified project performance categories such as people, cost, time, quality, safety and health, environment, client satisfaction, and communication. It is obtained by Navon (2005) that a control system is an important element to identify factors affecting construction project effort. For each of the project goals, one or more Project Performance Indicators (PPI) is needed. Cheung, Suen, & Cheung (2004) obtained that human factors played an important role in determining the performance of a project. Ugwu & Haupt (2007) remarked that both early contractor involvement (ECI) and early supplier involvement (ESI) would minimize constructability-related performance problems including costs associated with delays, claims, wastages and rework, etc.

2.4. Construction Project Manager and Project Performance

Mohd (2006) define Construction Project Manager as a person who is experienced in managing, monitoring, controlling of projects. He should able to coordinates and communicates the entire project process from the inception to the completion of the project which are including the project feasibility study, planning, design, coordinating the project team, controlling the project process, cash flow study, and many more towards the objectives of completing the project with high quality, minimum cost and within time.

Mohd (2006) stated that construction industry is often known as a very fragmented industry where it involves a huge numbers of activities with different types of parties and professional such as architects, engineers, quantity surveyor, contractor teams, suppliers, financiers and others. By looking at the fragmented industry and the needs to be competence in the globalize world; there is a need for management efficiency and competency to gain a higher level of competitiveness. The successful project managers should be able complete their project with high quality, minimum cost and within time. Most individual companies and organizations, which require the construction project services, did not have enough resources and expertise to carry out the role of the project manager to complete the projects with intended performance (Mohd, 2006). He marked that there should be a construction Project Manager to manage projects with the intention that projects get delivered efficiently on time, within budget and of the specified quality.

The project manager is the executive level for delegated authority from the client or top management. As such, it is his responsibility to generate the capacity and responsiveness in the project system (methods and procedures) to meet the performance requirements. The major challenge for every project manager is in the use of time and the allocation of all other resources to make the most productive use of the available time (Kuprenas, 2003).

2.5. Performance Management and Performance Measurement

2.5.1. Performance Management

Performance management is an agreement-based interactive control model. Its operational core is in the ability of the agreed parties to find the appropriate balance between the available resources and the results to be attained with them. The basic idea of performance management in operations is to balance resources and targets on the one hand and efficiency and quality on the other as well as possible and to ensure that the desired effects are cost-efficiently achieved (Azeb, 2016).

Performance management is a process for setting goals and regularly checking progress toward achieving those goals. It includes activities that ensure organizational goals and objectives are consistently met in an effective and efficient manner. The overall goal of performance management is to ensure that an organization and its subsystems (processes, departments, teams, etc.), are optimally working together to achieve the results desired by the organization (Azeb, 2016).

According to Azeb (2016), Performance management has a wide variety of applications, such as, staff performance and business performance. Because performance management strives to align all the subsystems to achieve results, the focus of performance management should also affect the management of an organization's performance overall. An organization can achieve the overall goal of effective performance management by continuously engaging in the following activities:

- Identifying and prioritizing desired results
- Establishing means to measure progress toward those results
- Setting standards for assessing how well results are achieved
- Tracking and measuring progress toward results
- Exchanging ongoing feedback among those individuals working to achieve results
- Periodically reviewing progress
- Reinforcing activities that achieve results, and
- Intervening to improve progress where needed (Azeb, 2016).

2.5.2. Performance Measurement

The purpose of performance measurement is to help organizations understand how decision making processes or practices led to success or failure in the past and how that understanding can lead to future improvements (National Research, 2005). Key components of an effective performance measurement system include these:

- Clearly defined, actionable, and measurable goals that cascade from organizational mission to management and program levels;
- Cascading performance measures that can be used to measure how well mission, management, and program goals are being met;
- Established baselines from which progress toward the attainment of goals can be measured;
- Accurate, repeatable, and verifiable data; and
- Feedback systems to support continuous improvement of an organization's processes, practices, and results (National Research, 2005).

Performance measures are recognized as an important element of all Total Quality Management programs. Managers and supervisors directing the efforts of an organization or a group have a responsibility to know how, when, and where to institute a wide range of changes. These changes cannot be sensibly implemented without knowledge of the appropriate information upon which they are based. In addition, among many organizations there is currently no standardized approach to developing and implementing performance measurement systems. As a result, performance measures have not been fully adapted to gauge the success of the various quality management programs practiced (Azeb, 2016).

As a process, performance measurement is not simply concerned with collecting data associated with a predefined performance goal or standard. Performance measurement is better thought of as an overall management system involving prevention and detection aimed at achieving conformance of the work product or service to customer's requirements. Additionally, it is concerned with process optimization through increased efficiency and effectiveness of the process or product. These actions occur in a continuous cycle, allowing options for expansion and improvement of the work process or product as better techniques are discovered and implemented (Azeb, 2016).

Performance measurement is primarily managing outcome, and one of its main purposes is to reduce or eliminate overall variation in the work product or process. The goal is to arrive at sound decision about actions affecting the product or process and its output (National Research, 2005).

The goal of Performance measurement system is to implement strategy. In setting up such systems, senior management selects measures that best represent the company's strategy. These measures can be seen as current and future critical success factors; if they are improved, the company has implemented its strategy. The strategy's success depends on its soundness. A performance measurement system is simply a mechanism that improves the likelihood the organization will implement its strategy successfully.

Comparing performance measurement systems to an instrument panel on a dashboard provides important insight about the mix of financial and nonfinancial measures needed in a management control system: A single measure cannot control a complex system; and too many critical measures make the system uncontrollably complex.

Performance measurement systems-like a dashboard and benchmarking-have a series of measures that provide information of many different processes. Some of these measures tell the manager what has happened. Other measures tell the manager what is happening (National Research, 2005).

Management theory and practice have long established a link between effective performance measures and effective management. The effectiveness of any given performance measure depends on how it will be used. For performance measures to have meaning and provide useful information, it is necessary to make comparisons. The comparisons may evaluate progress in achieving given goals or targets, assess trends in performance over time, or weigh the performance of one organization against another.

Performance measures used as a management tool need to be broadened to include input and process measures. One approach is to use an array or scorecard composed of multiple measures. The Balanced Scorecard is one such approach that assesses an organization and its programs from four different perspectives: customer, employee, process, and finance. The scorecard creates a holistic model of the strategy that allows all employees to see how they contribute to organizational success. It focuses change efforts. If the right objectives and measures are identified, successful implementation will likely occur.

The objectives and process for construction and construction project management create a good environment for the effective use of benchmarking for measuring and improving performance. Benchmarking is a core component of continuous improvement programs.

2.5.3. Benchmarks

Benchmarking is a key component of quality assurance and process improvement. The role of benchmarking in process improvement is similar to that of process improvement methodology. The methodology comprises five integrated steps:

- Define measure,
- Analyze,
- Improve, and
- Control

These steps are also central to the benchmarking process. Measuring, comparing to competition, and identifying opportunities for improvements are the essence of benchmarking (National Research, 2005).

Benchmarking is the process of comparing a company's performance against a benchmark to assess current performance and generate a plan to drive improvement in order to drive performance towards the benchmark level.

Benchmarking is a method of improving performance in a systematic and logical way by measuring and comparing performance against others, and then using lessons learned from the best to make targeted improvements.

It involves answering the questions: -

- 'Who performs better?'
- 'Why are they better?'
- 'What actions do we need to take in order to improve our performance?'

Essentially, it is about looking at the way things are done and seeing why the performance is at a certain level, and using external comparators to improve performance. It uses data as evidence to identify who is performing better and using that understanding to drive improvement.

A recent surge of interest in Benchmarking has been encouraged by the publication of sets of national Key Performance Indicators. Beginning in 1999, these benchmarks allow companies to measure their performance simply and to set targets based on national performance data (National Research, 2005).

Why do we need Benchmarking?

Benchmarking is not just about measuring performance. It is about comparing with others to drive improvement. Benchmarking is the process of comparing a company's performance against a benchmark to assess current performance and generate a plan to drive improvement in order to drive performance towards the benchmark level.

Benchmarking allows seeing how an organization is performing in a specific area, realistically comparing it, and finding ways of improving. This can affect all areas of the business from profitability, to staff satisfaction and retention.

A benchmark is a standard of excellence or achievement used to compare and measure against. It represents a best in class performance for a specific process that can be used to compare against in an effort to drive improvement. Some other definitions could be, A benchmark is a reference or measurement standard used for comparison.

A benchmark is ‘the best in class’ performance achieved for a specific business process or activity. It is performance that has been achieved and can be used to establish improvement goals (Swan, 2004).

When comparing between processes, there are three main types of benchmark to compare against,

- Internal – an internal benchmark is concerned with comparing against the best within an organization, such as the performance between different construction projects. The data is easy to collect and practices more easily transferred, however it is unlikely to be a spur for large scale innovation.
- Competitive – a competitive benchmark is comparing processes between organizations within the same industry. This will be directly relevant to processes, and could provide large levels of innovation. However, it is often difficult to collect comparative benchmarks unless a member of Benchmarking Club. An example of a competitive benchmark may be Health and Safety records.
- Generic – a generic benchmark is concerned with comparing the same or similar process, but within a different industry. This may lead to high levels of innovation, but there may be difficulties in adapting practices from radically different industries. An example of a generic benchmark might be a comparison between construction and aerospace supply chain management techniques (Swan, 2004).

When benchmarking internally, organizations benchmark against their own projects. When benchmarking externally, organizations seek projects from other companies or from separate program offices for comparative analysis. External benchmarks are generally considered to provide the greater advantage; however, internal benchmarking can be useful where no external benchmarks are available. Internal benchmarks are often the starting point for quantitative process examination. Trends can be identified by examining these data over time, and the impact of performance-improving processes can be assessed. External benchmarks provide the added advantage of comparing against competitors. Without external benchmarks, an organization and its managers may lack an understanding of what constitutes ‘good’ performance.

2.6. Factors Affecting Performance of Construction Project

Project performance can be measured and evaluated using a large number of performance indicators that could be related to various dimensions (groups) such as time, cost, quality, client satisfaction, client changes, business performance, health and safety (Cheung, Suen, & Cheung, 2004).

According to Mohammed (2004), the cause for the failure of performance of construction contractors are;

- Lack of experience in the line of work,
- assigning project leader in the site,
- labor productivity and improvement,
- use of project management techniques,
- procurement practices,
- claims,
- internal company problems,
- owner’s absence from the company,
- using computer applications,
- frauds,
- neglect,
- low margin profit due to competition,
- cash flow management,
- bill and collecting effectively,
- poor estimation practices,
- employee benefits and compensations,
- controlling equipment cost and usage,
- increased number of projects,
- increased size of projects,
- Change in the type of work,
- Lack of managerial maturity,
- National slump in the economy,

- Construction industry regulation and
- Bad weather.

Tawiah (1999) identified two main factors affecting contractor performance. The two factors were financial and managerial capacities of the firm. Under the financial factors contractor's financial stability in terms of access to credit was questionable and that has gone a long way to affect their performance over the years. Again under the managerial capacities, he identified site management practices, lack of technical expertise among others as factors influencing contractor performance in Ghana.

Shaban (2008) summarized from his research study the factors affecting the performance of construction projects in different groups. The main factors that listed under each group are as follows.

a. **Cost factors** include market share of organization, cash flow of project, profit rate of project, overhead percentage of project, project design cost, material and equipment cost, project labour cost, project overtime cost, cost of rework, cost of variation orders, waste rate of materials, cost control system, escalation of material prices, differentiation of currency prices, and liquidity of organization.
b. **Time factors** include site preparation time, planned time for construction, percentage of orders delivered late, time needed to implement variation orders, time needed to rectify defects, average delay in claim approval, average delay in payments from owners to contractors, unavailability of resources, and average delay because of closures leading to materials shortage.
c. **Quality factors** include conformance to specification, unavailability of competent staff, quality of equipment and raw materials, quality assessment system in organization and quality training/meeting.
d. **Productivity factors** include project complexity, management-labour relationship, absenteeism rate through project, number of new projects / year and sequencing of work according to schedule, local climate conditions, wedges amount, local cultural characteristics (non-working holidays), employees' motivation and employee attitudes.
e. **Client Satisfaction** factors include leadership skills for project manager, number of disputes between owner and project parties, speed and reliability of service to

owner, number of rework incidents, information coordination between owner and project parties.

f. **Regulatory and Community Satisfaction factors** include site condition problems, quality and availability of regulator documentation, cost of compliance to regulators requirements and number of non-compliance regulations.

g. **Health and Safety factors** include reportable accidents rate in project, application of health and safety factors in organization, assurance rate of project, easiness to reach to the site (location of project), wastes around the site, air quality and noise level.

h. **Innovation and Learning factors** include learning from own experience and past history, learning from best practice and experience of others, review of failures and solving them, work group, training the human resources in the skills demanded by the project.

Summary of Factors Affecting Performance of Construction Projects

From the above literatures review, there are different main and group factors affecting the performance of construction projects. From the literature review and application area experience, the following summarizations are the main and group factors that affect the performance of construction projects.

2.6.1. Cost Factors

- Market share of organization
- Cash flow of project
- Profit rate of project
- Material and equipment cost
- Project labor cost
- Differentiation of currency prices
- Project overtime cost
- Cost of rework
- Cost of variation orders
- Waste rate of materials
- Escalation of material prices

- Incomplete drawing

2.6.2. Time Factors

- Too many change orders from owner
- Poor project management assistance
- Unforeseen ground conditions
- Low speed of decision making
- Project complexity
- Effective communication
- Financial constraints
- Average delay in claim approval
- Average delay in payments from owner to contractors
- Site preparation time
- Unavailability of resources
- Time needed to rectify defects
- Time needed to implement variation orders

2.6.3. Quality Factors

- Conformance to specification
- Unavailability of competent staff
- Quality of equipment or machineries and raw materials
- Quality assessment system in organization
- Quality training or meeting
- Incomplete drawing
- Incomplete technical specification

2.6.4. Productivity Factors

- Project size and complexity
- Management-labour relationship
- Absenteeism rate through project (late start and early exists)
- Number of new projects per year
- Local cultural characteristics

- Non-working holidays
- Sequencing of work according to schedule
- Local climate conditions
- Employees motivation
- Employee attitudes

2.6.5. Client Satisfaction Factors

- Leadership skills for project manager
- Number of disputes between owner and project parties
- Speed and reliability of service to owner
- Number of rework incidents
- Information coordination between owner and project parties
- Conflict
- Poor workmanship and incompetence workers

2.6.6. Health and Safety

- Reportable accidents rate in project
- Application of health and safety factors in organization
- Assurance rate of project
- Easiness to reach to the site (location of project)
- Wastes around the site
- Climate condition and Air quality
- Noise level

2.6.7. Innovation and Learning

- Learning from own experience and past history
- Learning from best practice and experience of others
- Review of failures and solving them
- Work group.
- Training the human resources in the skills demanded by the project

2.7. Key Performance Indicators' in Construction Projects

Project performance can be measured and evaluated using a large number of performance indicators that could be related to various dimensions (groups) such as time, cost, quality, client satisfaction, client changes, business performance, health and safety. These key performance indicators enable for measurement of project and organizational performance throughout the construction industry. These KPIs can then be used for benchmarking purposes, and will be a key component of any organization move towards achieving best practice.

Cheung, Suen, & Cheung (2004) remarked seven main key indicators for performance which are: time, cost, quality, client satisfaction, client changes, business performance, and safety and health. Takim & Akintoye (2002) identified good project performance consists of seven key project performance indicators: construction cost, construction time, cost predictability, time predictability, defects, client satisfaction with the product and client satisfaction with the service. They also divide company performance indicators in to three, namely: safety, profitability and productivity.

From the literature review and application area experience, the main key indicators for performance of construction projects are Cost, Time, Quality, Productivity, Client satisfaction, Health and safety and Learning and Innovation

2.8. Model Forecasting Techniques

Variations in construction performances are the result of multiple factors. The relationship between influential factors and the resulting performance can be quantified through forecasting models. These models are efficient in decision making for estimating, scheduling, and planning future projects (Song & AbouRizk, 2008).

Construction industry experts and estimators may use their own conceptual model to judge the construction project performance under specific conditions. In fact, to develop an estimate, estimators evaluate these factors by forming a production process model in their minds (El-Gohary, Aziz , & Abdel-Khalek, 2017).

There are many modeling techniques available to study and quantify the relationship between influential factors and the corresponding rates, including the expectancy model, expert systems, action response model, statistical and regression models, and artificial neural networks (ANNs) (Heravi & Eslamdoost, 2015).

The expectancy and action-response models can only recognize the variability of rates, so cannot be used to quantify the relationship between multiple influential factors and the corresponding rates (Sonmez & Rowings, 1998). Expert systems have very limited capabilities to identify and map a function and generalize solutions.

2.8.1. Regression Analysis

There are various kinds of regression techniques available to make predictions. These techniques are mostly driven by three metrics (number of independent variables, type of dependent variables and shape of regression line) (Rasoo & Al-Zwainy, 2016).

a) Linear Regression

It is one of the most widely known modeling techniques. Linear regression is usually among the first few topics which people pick while learning predictive modeling. In this technique, the dependent variable is continuous, independent variable(s) can be continuous or discrete, and nature of regression line is linear (Palmer & O'Connell, 2009). Linear Regression establishes a relationship between **dependent variable (Y)** and one or more **independent variables (X)** using a **best fit straight line** (also known as regression line). It is represented by an equation.

$$\mathbf{Y = a + b*X + e} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where: a is intercept, b is slope of the line and e is error term.

b) Logistic Regression

Logistic regression is used to find the probability of event=Success and event=Failure. We should use logistic regression when the dependent variable is binary (0/ 1, True/ False, Yes/ No) in nature. Here the value of Y ranges from 0 to 1 and it can represent by following equation. Odds= p/ (1-p) = probability of event occurrence/ probability of not event occurrence (Palmer & O'Connell, 2009).

$$\mathbf{Ln\ (odds) = ln\ (p/\ (1\text{-}p)) = Logit\ (p) = ln\ (p/\ (1\text{-}p)) = b_0+b_1X_1+b_2X_2+b_3X_3....+ b_nx_n} \ldots\ldots\ldots\ldots (2)$$

Where; p is the probability of presence of the characteristic of interest.

2.8.2. Hybrid SD-DES Simulation

DES is one simulation technique widely used when evaluating potential financial investments, operations research, and modeling procedures and processes in various industries. This kind of modeling is frequently employed, for example, in the manufacturing, construction, and healthcare industries. DES can be defined as the process of codifying the behavior of a complex system as an ordered sequence of well-defined events (Brito, et al, 2010). In the hybrid SD-DES modeling approach, capabilities of one model cover shortcomings of the other to provide more accurate results for system analysis (Alvanchi, Lee, & AbouRizk, 2011). To achieve more realistic assumptions, Discrete Event Simulation (DES) was used for modeling the operational parts of the system and System Dynamics (SD) for modeling the nonoperational parts of the system (i.e., feedback); this combination is called the hybrid SD-DES modeling approach (Moradia, Nasirzadehb, & Golkhooc, 2017).

Various types of hybrid modeling format among hierarchical, phase to phase, or integrated hybrid SD-DES format should be selected. For more details on the mechanism of the interactions between DES and SD parts. Modeling construction operations is one of the ways in which DES is very useful in the construction industry DES has been recognized as a very useful technique for quantitative analysis of operations and processes that take place during the life cycle of a constructed facility (Kisi, 2015).

2.8.3. Structural Equation Model

SEM is a multivariate technique developed by psychologists and sociologists to estimate a quantitative interdependent relationship between independent variables. The SEM consists of two components: a measurement model and structural model. The factor analysis provides the measurement model, which is concerned with how well the defined components (exogenous variables) measure latent variables (Meyers & Guarino, 2006).

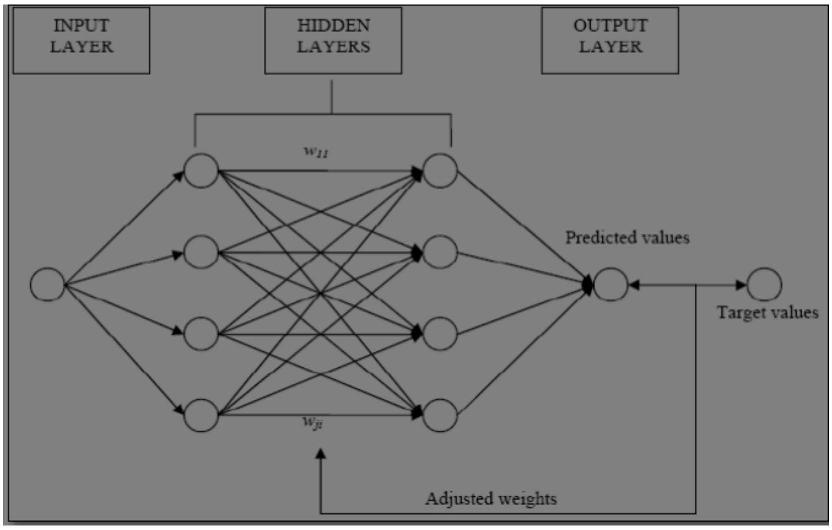
1. **Artificial neural network**

Artificial neural networks (ANNs) offer an approach to computation that is different from conventional analytic methods. ANNs are an information processing technology that simulates the human brain, and the nervous system. Like the human brain, neural networks learn from experience, generalize from previous examples to new ones and abstract essential characteristics from inputs containing irrelevant data. Muller & Reinhardt (1990) as cited in Rifat (1996) neural network models are algorithms for cognitive tasks, such as learning and optimization that are based on concepts derived from the research into the nature of the brain.

Neural networks have the capability of learning from a number of input patterns (representing different problem encounters) and their associated output patterns (representing the conclusions and decisions). During the process called training, the network generalizes the knowledge, and becomes capable of providing solutions to the new problems even if only incomplete or noisy data are available. Once a network is trained using an adequately representative training set, it can be used to classify or to predict the output of the modeled system for a given input pattern. One of the attractive properties of such networks is their capacity for tolerating moderate amounts of noise, and variations in the input. Neural networks provide a variety of powerful tools for optimization, function approximation, pattern classification, and modeling. Neural network models have been developed and used as an alternative to regression analysis since the back propagation algorithm was proposed.

According to El-Gohary, Aziz , & Abdel-Khalek (2017) neural networks are a series of interconnected processing elements (artificial neurons) in a number of layers. NNs are trained using available data to understand the underlying pattern see figure below.

Figure 2.1 General structure of neural network.



2.9. Review on Previous Forecasting Models

Weshah, et al (2014) identified the top ten interface problems that affect performance of a project. It includes enhancing project performance by developing and applying multiple regression analysis models between the underlying interface problem factors and the project performance indicators. The last phase includes measuring the severity of the impact of each problem to develop a risk analysis model. The results of the multiple regression models indicate that the interface problems caused by the "technical engineering and site issues factor", the "bidding and contracting factor", and the "information factor" were the strongest influences on the schedule and cost project performance indicators.

Kim, et al (2009) produced a model to predict the key performances of construction projects in Republic of Korea, using an SEM approach. The authors used data extracted from 126 construction projects to develop the SEM, and an additional 15 sample projects were used to test the model. The authors identified key variables based on the structural coefficients that significantly determine the success of an overseas project. The primary variables drawn from the study are: attitude and ability of owner and A/E, commitment of organization, project information in early stage, and appropriateness of cost management.

Sarhan, Abdulmajeed, & Aljumaily (2013) developed a model for estimating construction productivity for finishing works by using a multi-variate regression analysis technique in Iraq. The study uses factors that affect construction productivity as independent variables to create a relationship. They used literature reviews and questionnaire to list out the factors and statistical package for social studies (SPSS) software for data analysis and comparison of the collected data. As per their findings, the model they developed is good and the predicted values from a forecast model fit with the real-life data.

Sandersand & Thomas (1993) used an additive regression technique to develop a forecasting model for masonry construction in central Pennsylvania. There were four major categories in this paper; work type, physical elements, construction methods and design requirements. They formulated a statistical model that forecasts productivity of masonry activities based on data collected from 11 masonry projects. The model has a predictive ability R^2 value of 41.1% and was tested by predicting productivity of 11 projects with seven of the 11 being predicted with 10% of the actual productivity.

Han, Kim, & Kim (2007) develops a model that can allow construction firms to screen out bad projects when the warning signals of failure are detected early by paying attention to critical factors. This prediction model can assign weights to every risk factor embodied as an application and so provide a prompt management guideline for construction companies just by answering 64 questions regarding the profit-influencing variables at the early stage of project initiation. Despite its advantages, however, this forecasting target is focused on the scale-based success level of projects because real earnings ratio could not be collected due to companies' privacy and confidential policy about actual profit rates. In addition, this paper develops a model for general types of overseas projects due to the limited sample data.

2.10. Gap Analysis

As it is studied in different countries, construction projects worldwide have been experiencing significant cost and time overruns due to different factors that affects the performance of the projects (Mekides, 2016).

In order to improve construction industry, assessing significant factors that affects performance has a significant role due to the fact that the construction industry involves an employment of huge number of employees to carry out the work. In line with this all the related stakeholders of the construction industry including the government should take their parts in the improvement of construction labor productivity.

Like other countries, the construction industry in Ethiopia has a significant role in the development of other industries. Accordingly, the improvement of the growth of the construction industry contributes for the growth of many other sectors. Improvement of construction performance is therefore critical. A critical attention should be given by the construction professionals in Ethiopia to improve the performance in the construction projects and in order to improve the construction performance identifying the influencing factors is very vital.

There are many papers done on identifying factors that affects construction performance of both building and road projects in different cities and regions of the world and also there were many literatures that developed a forecasting model using different mechanisms like SD-DES, SEM, ANN, MLR and others. Also, in our country Ethiopia, there were some studies that investigated factors affecting construction performance.

The literatures that established the model used past (previous years) construction data to develop the model, and it is researcher's view that using the previous year's data can be somehow outdated because there would be some fluctuation on different factors contributing to construction performance, that's why this paper was done on ongoing road construction projects. And the researcher also observed that there is a gap on developing a model that predicts and measures construction performance of road projects. So, the researcher took this as a gap and decided to investigate factors affecting construction performance and develop a forecasting model that predicts construction performance of road construction projects located in Central Division of Ethiopian road authorities category.

3. Methodology

3.1. Introduction

This section describes the procedures needed to be undertaken to achieve the objectives of the study. The procedures to adopt, including all the information relevant to the data collection and where those data were obtained are discussed. In addition, data and information sources, research instruments, sample size and method of analysis are presented.

3.2. Identifying the Problem Statement and Objectives

Developing problem statement and objectives are the first steps in this research. This can be done in various ways but in this particular research, reading materials and personal perspective or observation play very important roles.

From personal exposure and perspective or observation, project performance seems to be a big problem in construction industry. Being involved in the construction industry with consultant, contractor and owner before, project performance problems seems to be endless. Based on this, I decided to initiate the research in this particular issue.

Problem statement was then developed. A developed written statement from this research would then be determined. Later stage was to develop objectives of the research. The next step in this research proposal was to do some literatures reviews to get deeper information about the issue of the study.

3.3. The Study Approach and Source of Data

Study explains to some level of understanding the cause of construction performance problems in Ethiopian Federal construction projects. Inductive survey established on cause and impact of construction performance failure in these construction projects with diligent investigation, attempting to collect facts.

To improve the validity of study findings, the combination of qualitative and quantitative methods will be adopted to the study. For the following basic document will be collected: respondent's documents and archival documents. The respondents' documents will be collected using questionnaires from clients, contractor and consultants. Study questionnaire survey will have both open ended and closed ended questionnaires. Archival documents are mostly from completed project contract document, monthly reports, correspondence letters, consultancy completion reports and payment certificates will be investigated thorough which are very important in identifying the frequent problems related performance failure in Road construction projects.

3.4. Research Type

The research tries to explore, examine and identify the major problems of project performance, the causes and effects of project performance failure and remedial measures to improve project performance in construction projects, and it implements more of descriptive, exploratory and both qualitative analysis and quantitative approach.

3.5. Sources of Data and Data Collection Approach

The study will examine the cause of performance failure on ongoing Federal Road construction projects to achieve the study objectives the following instruments were used;

Observations: For the purpose of this research apart from the contract document and monthly progress reports review, Observation of construction Progress was conducted on some of the selected sample projects.

Questionnaire: The questionnaires were two phase, the first was distributed to select the most significant factors affecting Performance of Federal Road Projects in Central Division (Region). Questions used in the 1st questionnaire contain 'close ended' (based on Likert scale) and open-ended questions. Document Reviews were thoroughly conducted to collect relevant secondary data from secondary sources (reports, books, journals, reports, contract documents). The questionnaire used in this study was based on the literature review and some insights collected from experts in the field and focused on gathering information from Site supervisors, Project managers, Site engineers, experienced foremen and skilled labours.

The second questionnaire was distributed after the most significant factors were determined by RII. It was intended to collect real (actual) data from road construction projects regarding Performance of projects. Both questionnaires are attached at the end in Appendices.

Interviews: There were mainly unstructured interviews conducted on some road projects. The interviews were focused on collecting relevant data from experts (project managers, site engineers and experienced foremen), which were used in developing the first questionnaire.

3.6. Population of the Study

The populations used in this study are Road construction projects in federal level and participants such as, owners, contractors and consultants of projects. The population in this study will be all ongoing Central Division Road projects in Ethiopia and its participants such as, owners, contractors and consultants of the selected project.

3.7. Sample Size Determination

Sampling is the process of selecting representative units of the population for the study in research investigation. A sample is a portion of a population selected for observation & analysis.

The sampling technique used in this study was simple random sampling so as to give each project an equal and an independent chance of being selected. The sample size of the study was determined by using international research sample size determination formula. Therefore, the sample size was determined by the simplified international research sample size determination formula (Taro yamane, 1967).

$$n=N/(1+N\times e^2) \qquad \ldots\ 3.1$$

Where; n= sample size

N= Total population size

e= Acceptable level of error (which is 5%)

The total target population the researcher got from Ethiopian Road Authority is 35 active on-going construction projects. Considering the three main stake holders in each project, the total Target population becomes 105. Therefore, the sample size for the research is:

$$n = N/(1+N\times e^2)$$

$$n = 105/(1+(105*0.05^2))$$

<u>n = 84</u>

3.8. Data Measurement

For this study, ordinal scales will be used for data measurement. Ordinal scales as shown in the tables are a ranking or a rating data that normally uses integers in ascending or descending order. The numbers assigned (1, 2, 3, 4, 5) do not indicate that the interval between scales are equal, nor do they indicate absolute quantities. They are merely numerical labels. Based on Linker scale there are following tables.

Ordinal scale used for the measurement of rate of occurrence of performance related problems:

Table 3.1: Rating scale for project performance problems

Item	**Never**	**Sometimes**	**Usually**	**Frequently**	**Most Frequently**
Scale	1	2	3	4	5

Ordinal scale will be used for the measurement of the effect of the occurrences of performance related problems to determine the key performance indicators of Road construction projects:

Table 3.2: Rating scale for factors affecting project performance

Item	**Very Low Impact**	**Low Impact**	**Medium Impact**	**High Impact**	**Very High Impact**
Scale	1	2	3	4	5

3.9. Instrument Validity and Reliability

The two most important concepts that are used to evaluate the quality of the research are Validity and Reliability. They indicate how well a method, technique or test measure something.

Validity: refers to how accurately a method measures what it is intended to measure. In order to enforce the research, the used survey instrument should be piloted to measure its validity and reliability and test the collected data. A pilot study provides a trial run for the questionnaire, which involves testing the wording of question, identifying ambiguous questions, testing the techniques that used to collect data and measuring the effectiveness of standard invitation to respondents (Mohaffyza, Sulaiman, & Sern, 2018).

The pilot study was done by distributing the prepared questionnaire to panels of experts having experience in the same field of the research to collect their remarks on the questionnaire. The pilot study was done before collecting the final data of the whole sample. The piloting process was conducted through many interviews with the stakeholders from different projects and they were provided with an explanation about the inclusion of the data and the objectives of this study and had been asked to fill the questionnaire. The respondents were given the opportunity to add their suggestions about the questionnaire form and contents. All the suggested modifications and comments were discussed with advisors before taking into consideration. The piloting stage served to increase the effectiveness of the questionnaire.

Reliability: refers to how consistently a method measures something. If the same result can be consistently achieved by using same methods under same circumstances, the measurement is reliable. Internal consistency of the data was measured by Cronbach's alpha, a statistic calculated from the pairwise correlations between items. With the help of Cronbach's alpha coefficient, the reliability of data measuring instruments was assessed. SPSS was used to calculate Cronbach's alpha and a value of **0.831** was found. According to Mohaffyza, Sulaiman, & Sern 2018) this value of cronbach's alpha is more than acceptable.

3.10. Data Analysis

This research is quantitative in nature. As such the data gathered was put in a numerical form for the purposes of analysis. The relative importance index method (RII) will be used to determine and rank the performance problems, the factors that affect project performance and key performance indicators in Road construction projects and all will be analyzed by MS-Excel and SPSS.

The relative importance index is computed using equation

$$RII = \frac{\Sigma W}{A*N}$$

Where:

RII is relative importance index,

W is the weight given to each factor by the respondents and ranges from 1 to 5

A = the highest weight = 5

N = the total number of respondents. (Cheung, Suen, & Cheung, 2004).

The most commonly used methods to measure the relationship between variables are Spearman Rank's Correlation Coefficient method and Pearson's correlation. I will use Spearman Rank's Correlation Coefficient method because it's often used to evaluate relationships involving ordinal values.

Spearman Rank's Correlation Coefficient method, which values varies between -1 and +1, was used to know owners, consultants and contractors perceptions of project performance related problems, factors that affect project performance and the key performance indicators of selected ongoing Road construction projects in Ethiopia. The Spearman's Rank Correlation Coefficient is computed using equation 3.2

$$r_S = 1 - \frac{6\Sigma(d^2)}{n''(n''-1)} \quad \text{.................................. equation 3.2}$$

Where:

r_S is Spearman's Rank Correlation Coefficient,

d is the difference in the factors ranks given by the respondents, and

n" is the number of data pairs.

- A correlation coefficient of +1 means perfect positive correlation.
- A correlation coefficient close to 0 means no correlation.
- A correlation coefficient of -1 means perfect negative correlation. (Crawshaw & Chambers, 2001).

There are several model formulation methods used by different scholars. It was seen that the most popular methodology for Productivity models is the parametric analysis techniques like linear regression analysis (simple and multiple), and neural networks. In this research the method of data analysis adopted was the principal component analysis (PCA) method.

3.10.1. Principal Component Analysis (PCA)

Principal component analysis: is a method that combines principal component analysis and multiple linear regression analysis. According to Sonmez & Rowings (1998), PCA establishes a relationship between the output variable and the selected principal components of the input variables. In this research the principal component regression method was used basically to avoid the problem of multi-collinearity often associated with using multiple linear regressions to formulate prediction models.

Multi-collinearity as defined by Rasoo & Al-Zwainy (2016) is a condition wherein one or more of the independent variables can be approximated by a linear combination of other independent variables. Hence using principal component analysis (PCA) method prevents the likely occurrence of multi-collinearity when multiple linear regression analysis (MLR) is used to determine the nature and strength of the relationship between the dependent variable and independent variables.

Therefore, the data analysis procedure adopted for this study was, firstly, the PCA method was used to identify the principal components of factors having a significant relationship with construction labor productivity. Next, multiple linear regression (MLR) analysis was carried out taking into consideration the results of the PCA. Data analysis was conducted using a software application called statistical package for social sciences (SPSS) for windows and Microsoft Excel. SPSS software was used as a statistical tool to carry out the data analysis for construction duration model development.

Principal Component Analysis (PCA) of Factors

Principal component analysis (PCA) is a traditional multivariate statistical method commonly used to reduce the number of predictive variables and solve the multicollinearity problem. According to Brito, et al (2010), PCA looks for a few linear combinations of the variables that can be used to summarize the data without losing too much information in the process.

The principal component analysis of factors involves three main steps, namely; testing for the appropriateness of using PCA, extraction of factors/principal components and selecting the principal components to be used in the regression analysis.

Testing for the Appropriateness of using PCA

The appropriateness of using PCA in terms of the correlation matrix of a given data set according to Alvanchi, Lee, & AbouRizk (2011), is achieved via the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity. The KMO varies between 0 and 1. According to Alvanchi, Lee, & AbouRizk (2011), the recommended values of KMO for accepting the appropriateness of PCA is as; KMO values greater than 0.5 as acceptable, values between 0.5 and 0.7 as mediocre, values between 0.7 and 0.8 as good, values between 0.8 and 0.9 as great and values above 0.9 as superb while for KMO values below 0.5 additional data needs to be collected as the use of PCA will be inappropriate.

Similarly, the Bartlett's test of sphericity tests the null hypothesis that the original correlation matrix is an identity matrix (a matrix in which all the correlation coefficients are zero, except the diagonal which will be one all through). The significance level of this test will therefore determine if PCA will be appropriate or not, i.e., the use of PCA will only be appropriate if the test is significant at a p-value less than 0.05.

Extraction of Principal Components

PCA extracts from a set of *p* variables a reduced set of *m* principal components that account for most of the variance in the *p* variables as stated in (Moradia, Nasirzadehb, & Golkhooc, 2017). The eigenvalues associated with each factor in the set of *p* variables as well as the scree plot, is usually used as a guide to determine the reduced set of *m* principal components or factors that account for most of the variance in the set of *p* variables.

The eigenvalue associated with each variable represents the variance explained by that particular variable. Independent variables with eigenvalues greater than one are recommended to be accepted. The scree plot on the other hand is a plot with eigenvalues on the ordinate and component number on the abscissa. The point of inflection at which this plot begins to tail off, signifies the point at which variables/linear components with eigenvalues greater than one end (Alvanchi, Lee, & AbouRizk, 2011).

Selecting Principal Components

Following the second step, the extraction of the principal components, the last step is to examine those variables/linear components and then select the most significant variables/linear components to be used in the multiple linear regression analysis. In order to select the most significant variable, the criterion for selection according to Kisi (2015), is selecting the variable component with the biggest correlation coefficient in the rotated component matrix.

3.10.2. Multiple Linear Regression (MLR) Analysis

Regression analysis is a technique that finds a formula or mathematical model which best describes a set of data collected. There are various kinds of regression techniques available to make predictions. These techniques are mostly driven by three metrics; namely; the number of independent variables, the type of dependent variables and the shape of regression line. These regression techniques include; simple linear regression, multiple linear regression, logistic regression, polynomial regression, etc.

For this study the multiple linear regression (MLR) analysis method was adopted to determine the nature and strength of the relationship between dependent variable (construction duration) and a combination of independent variables/factors. The multiple linear regression analysis is conducted to quantify the relationship between one dependent variable and more than one independent variable.

The most significant factors to be used for MLR analysis were selected based on the results of PCA method. In multiple linear regression analysis, a common goal is to determine which independent variables contribute significantly to explaining the variability in the dependent variable. As outlined by Meyers & Guarino (2006), the multiple regression model for a response variable, Y, with observed values, $y_1, y_2, \ldots,$ y_n (where n is the sample size) and q explanatory variables, $x_1, x_2, \ldots, x_n$ with observed values, $x_{1i}, x_{2i}, \ldots, x_{ni}$ for i = 1,2, …, n, is given by:

$$Y = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots\ldots + \beta q\, x_{ni} \qquad \ldots\ 3.2$$

Where; Y is the dependent or response variable,

x_1, x_2, x_n are the independent or explanatory variables and

βi's are the respective regression coefficients.

Assumptions of MLR Analysis

The developed regression model should be tested before considering it as a construction duration forecasting model. This testing is based on the assumptions made during multiple linear regression analysis. There are four principal assumptions which will justify the use of multiple linear regression models for purposes of prediction. The assumptions made in multiple linear regression analysis are;

- Assumption of Linearity,
- Assumption of Outliers,
- Assumption of multicollinearity and,
- Assumption of Normality.

If the above MLR assumptions are not satisfied, then the forecasts and confidence intervals yielded by a linear regression model may become inefficient and misleading (Muller & Reinhardt, 1990). Resulting regression models must thus, be tested for each of these assumptions and in the event where any of these assumptions is being violated, appropriate measures must be used to fix the problem.

✓ **Checking for Linearity assumption**:

In the scatter plot diagram, if the pattern of the scattered points forms a roughly rectangular distribution with most of the scores clustered in the center indicating a linear relationship then, the assumption of linearity is met. Here the pattern of the scattered points should not be like a curving pattern; hence, a curving pattern indicates nonlinearity.

✓ **Checking for Normality assumption**:

In the normal probability plot, if all of the residuals fall within the confidence bands for the normal probability plot, the normality assumption is met or if the points lie reasonably closer to the line then the normality assumption is met. Normality may or may not be met, but probably not fatal to using the model.

✓ **Checking for Outlier assumption**:

An outlier is an extreme observation, different from other observations in the data set. They can usually be identified from the residual plots. Outliers are checked by using the Mahalonobis distance that is produced by the multiple regression programs.

The Mahalonobis distances are converted to chi-square values for analysis. Chi-square is a calculation used to determine how closely the observed data fits the expected data. The numbers of independent variables are associated with the critical values of chi-square. Therefore, if there are more than two percent cases with a higher Mahalonobis distance than the critical one, then the outliers' assumption will not hold true. In order to remove an existing outlier, transforming the data set is often considered as a better solution.

- ✓ **Checking for Multicollinearity assumption**:

At the multicollinearity section, if any variable has a variance inflation factor (VIF) greater than 10, collinearity could be a problem. Also, if the variable has a tolerance value of less than 0.10, then there is a multicollinearity problem.

Regression Model Assessment Criterion

The models developed using the different regression techniques should be assessed in order to select the best model. The model assessment criteria used to choose the best out of the models generated include the following; correlation coefficient (R), coefficient of determination (R2) and significance of value (p-value).

- **Correlation Coefficient (R) criterion:** This is the measure of the association between a dependent variable and independent variable (Durdyev, Ismail, & Kandymov, 2018). It is an acceptable measure of the reliability of a regression equation. The coefficient range is $(0 \leq R \leq 1)$.
- **Coefficient of Determination (R^2) criterion:** R^2 is the percentage of response variable variation that is explained by its relationship with one or more predictor variables. Durdyev, Ismail, & Kandymov (2018), states that R^2 is also a measure of the proportion of variation in the dependent variable that is explained by the behavior of the independent variable. Usually, the higher the R^2, the better the model fits the data. R^2 is always between 0 and 100%. The more variance that is explained by the regression model the closer the data points will fall to the fitted regression line. R^2 gives an indication of the predictive capability of the regression model using new observations (Enshassi, et al, 2007).
- **Significance of value (p-value) criterion:** This is used to determine the significance of a regression equation by testing whether the developed regression

model is significant or (Enshassi, et al, 2007). To ascertain the significant level, p-value calculated is compared with the critical value of p-value (p-value tabulated) at 5% level of significance. Therefore, if the p-value is less than 0.05, then the model does a good job predicting the outcome better than just chance.

Model Adequacy Check and Validation

Once the MLR model is developed, the model adequacy should be checked before applying the model for actual purpose. The purpose of model validation is to ascertain the performance of the model. According to AL-Zwainy, Rasheed, & Ibraheem (2012), the model validation can be achieved by using the following basic techniques. The techniques used were; by checking the fulfillment of the assumptions made in the multiple linear regression analysis modeling process and by splitting the original data into two to measure the predictive accuracy of the model using statistical parameters.

Data Splitting Method

According to Heravi & Eslamdoost (2015), data splitting is the process by which the data population is divided into estimation and prediction data sets for regression analysis and validation, respectively. The set of estimation data is used to complete the statistical regression analysis while the prediction data set is used to validate the model and ensure that the models prepared reflect reality. 80% of the data according to Heravi & Eslamdoost (2015), is used for developing the model, while the remaining 20% is used for validating the developed model. For this study, the method of data splitting was also used for checking the validation of the developed model. The original data was split into two; one set for model calibration and the other set for model validation.

The statistical parameter used for checking model adequacy was the mean absolute percentage error (MAPE) value of the model. The MAPE value was used to find the closeness of fit to the model and to test the reliability of the model. MAPE usually expresses accuracy as a percentage, and is defined by the formula:

$$\text{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{P_i - A_i}{A_i}\right| * 100 \qquad \ldots 3.3$$

Where, Ai is the actual value,

Pi is the predicted value,

n is the number of validation projects, and

MAPE is the mean absolute percentage error, expressed in percentage.

3.11. Ethical Consideration

There are ethical considerations that the researcher will consider before, during and after conducting the research to ensure he does not infringe upon either parties' interest or business. The research was conducted in a professional manner and high standards to ensure the document is in line with the ethical standards. The research was done in accordance with the objective and focused towards the main subject of the research. This means that the researcher ensured that they concentrate solely on the research question or the subject of the research without making any other forms of research, which may not be within the specific research originally intended to be conducted.

The participants of the research were not put to harm in any ways whatsoever. And their dignity and full consent was prioritized in advance. There was not any use of offensive, discriminatory or other unacceptable language in the formulation of questionnaire and interview. Acknowledgment of work of other authors used in any part of the research was done using APA referencing style.

4. Results and Discussion

4.1. Introduction

This chapter describes the results and discussion of desk study and questionnaire survey concerning construction performance challenges in Ethiopian Federal Road projects from contractors, consultants and client viewpoints. Each part of questionnaire answers the research questions and achieves the objectives of the research. The tables show participants' Relative Importance Index (RII) and rank of project performance problems, factors affecting project performance, key performance indicators and correlation between respondents in each part. And the figures show the combined RII and ranks. The discussions are drawn from the combined RII and on the top rank, correlations between the respondents and perceptions of the respondents in each group factors that affects project performance. Two different ways were used to analyze the survey results.

i. Ranking of the various factors according to their significance, and calculating their Relative Importance Index (RII)

ii. Based on the RII value, using the top factors having RII greater than or equal to **0.80** are selected for modeling part of the research

4.2. Respondent Backgrounds and Response Rate

Part one of the questionnaire is intended to obtain general information about the involvement of the respondents. It consists of information related to their position in the organization, organization type, and work experience in Road sector.

A total of 105 questionnaires were sent to the three groups of respondents who involved in the current Road construction projects in Ethiopia. Hence there were 35 Federal Road construction projects in Central Region at the time of data collection, 35 questionnaires were distributed for contractors of each project, 35 for consultants in all site and 35 for client representatives (Ethiopian Road Authority Representatives). Out of 105 questionnaires, 90 questionnaires were collected which comprises 32 from client representatives, 28 from contractors and 30 from consultants.

Before starting the analysis, the returned questionnaire was checked for their reliability and all responded questionnaires were found to be suitable for data analysis. This gives a response rate of 80% as shown in Table 4.1 below.

Table 4.1 Distribution and response rate of questionnaire

Category	Questionnaire Distributed	Questionnaire Returned	Valid Responses	Percentage Returned (%)
Client	35	32	30	86%
Contractor	35	28	25	72%
Consultant	35	30	29	83%

Total	105	90	84	80%

Various experienced professional levels were targeted to fill the questionnaire survey. Out of the total questionnaire disseminated, 65% of professionals were from organizations of more than 15 years of establishment, 31% from organizations of more than 10 -15 year of establishment and 4% of them were from were from organizations of more than 5 -10 years of experience.

In regard to educational background, M.Sc. and B.Sc. degree holders' accounts to 58% and 33% of the valid respondents number respectively.

In terms of the respondent's position they hold at the time of the survey in the organization, about 74% were at the top management managerial level while the remaining 26% were at their middle managerial level.

The reliability and accuracy of the survey is believed satisfactorily accurate as 74% of the respondents are from top management level such as Region Director, Team Leader, Counter Part, General Managers, Project Managers and Resident Engineers that are directly involved in contract management and 65% of the professionals are from organizations that have more than 15 years of establishment within the road construction industry of Ethiopia.

Therefore, relevant pertinent knowledge and expert information are believed compiled for the analysis in order to draw reliable conclusions and recommendations.

4.3. Project Performance Problems in Road Construction Projects

In this part, the results of the questionnaire survey are discussed regarding to the performance related problems in Road construction projects. This part of study provides an indication of the participants' and combined relative importance index (RII) and rank of performance related problems in Road construction projects and correlation coefficients between the stake holders.

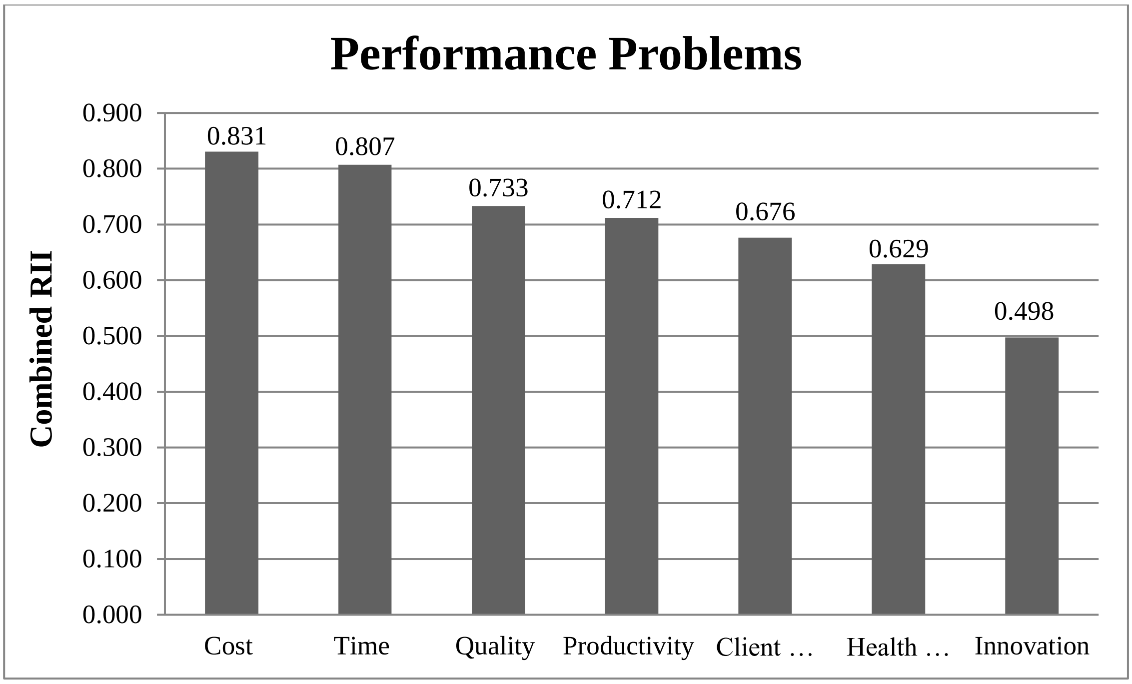
There are seven project performance problems in construction projects that were identified from the literature reviews and the major problems in Ethiopian Federal Road construction projects based on the questionnaire survey are discussed below.

Table 4.2 and figure 4.1 shows summary of the participants' RII combined RII and rank of performance problems. After the figure the discussions are made on the top and major performance problems ranked by the respondents.

Table 4.2 Participants' RII, combined RII and rank of project performance problems

No.	**Performance Problems**	**Client**		**Contractor**		**Consultant**		**Combined RII**
		RII	**Rank**	**RII**	**Rank**	**RII**	**Rank**	
1	Cost	0.827	1	0.872	1	0.800	2	0.831
2	Time	0.807	2	0.840	2	0.779	3	0.807
3	Quality	0.760	3	0.696	4	0.738	4	0.733
4	Productivity	0.687	5	0.776	3	0.683	5	0.712
5	Client Satisfaction	0.733	4	0.440	6	0.821	1	0.676
6	Health and safety	0.620	6	0.664	5	0.607	6	0.629
7	Innovation and Learning	0.573	7	0.400	7	0.503	7	0.498

Figure 4.1 Combined RII and rank of project performance problems



From the table 4.2 shown above, both client and contractor ranks cost problems in construction projects are the major problems that highly affect the performance of the project. Time, Quality and Productivity related problems also appear in top five major construction problems by all three stake holders (Client, Contractor and Consultant).

From the combined result shown on figure 4.1, the major performance problems which have been occurred on the projects are cost and time with a combined RII of 0.831 and 0.807 respectively. Following to cost and time; quality (0.733), productivity (0.712), client satisfaction (0.676) and health and safety (0.629) are other major performance problems. The least, but the important performance problem has been innovation and learning (0.498). The reasons for these results of major performance problems will be discussed in detail later this chapter.

The other point evaluated in this section is the opinion of different stakeholders' and their deviation from one another regarding performance problem of Road projects. The spearman correlation coefficient is used to quantify the differences of opinions between these parties as shown in the table 4.3 below.

Table 4.3 Spearman correlation coefficient of project performance problems

	Client	Contractor	Consultant
Client	1.00	0.82	0.79
Contractor	0.82	1.00	0.43
Consultant	0.79	0.43	1.00

On table 4.3, the spearman correlation coefficient indicates that there is strong relation between the responses of Client-Consultant, moderate relation between contractor-client and weak relation between contractor-consultant.

The strong relation between client and consultant indicates that they have the same attitudes and perceptions towards the performance problems. This is because of most of consultants are the representatives to clients and act as them.

Even if client and contractor doesn't agree much in most construction projects, table 4.3 shows as there is a moderate relation between contractor-client. The reason behind this is most problems stated above (especially cost, time and quality) affect both parties at a comparable rate.

The weak relation of contractor to consultants implies that contractors have too different attitudes and priorities with consultants. Based on the Data collected, Consultants mostly give priority for client's satisfaction but contractors gives more attention for productivity and health & safety rather than client's satisfaction and contractors mainly challenged due to the occurrence of these problems.

4.4. Key Performance Indicators' in Road Construction Projects

In this part, the results of the questionnaire survey are discussed regarding to the key performance indicators (KPI) in Road construction projects. This part of study provides an indication of the participants' and combined relative importance index (RII) and rank of key performance indicators in Road construction projects and correlation coefficients between the stake holders.

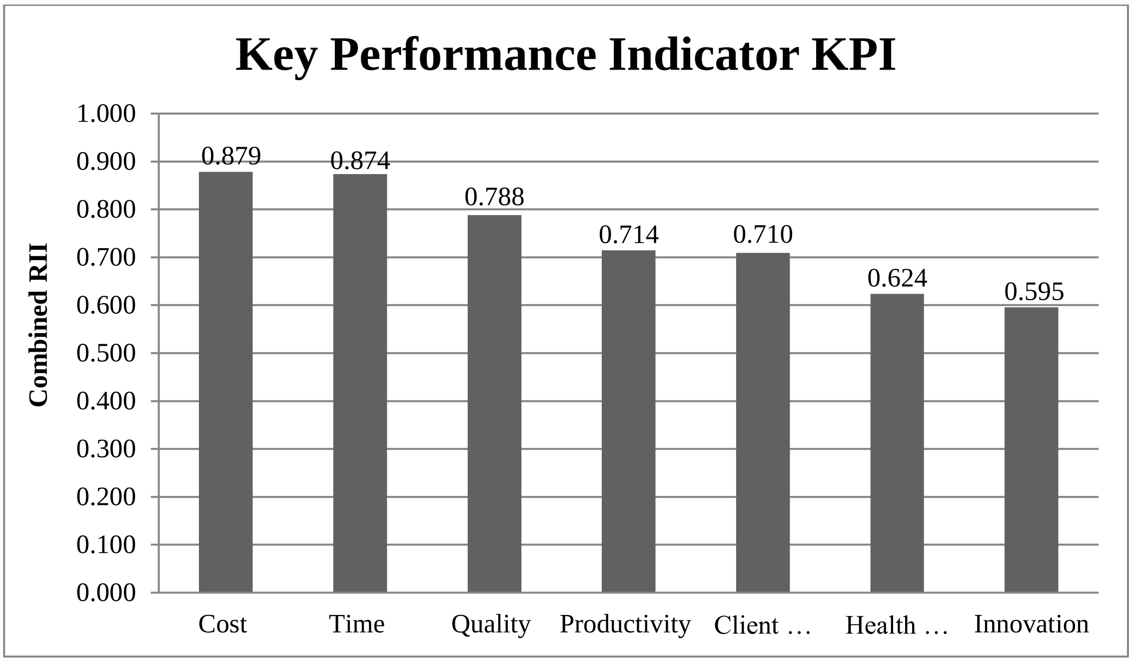
There are seven Key performance indicators (KPI) in construction projects that were identified from the literature reviews and the major problems in Ethiopian Federal Road construction projects based on the questionnaire survey are discussed below.

Table 4.4 and figure 4.2 shows summary of the participants' RII, combined RII and rank of performance problems. After the figure the discussions are made on the top and major performance problems ranked by the respondents.

Table 4.4 Participants' RII, combined RII and rank of Key performance indicators (KPI)

No.	Key Performance Index KPI	Client		Contractor		Consultant		Combined RII
		RII	Rank	RII	Rank	RII	Rank	
1	Cost	0.853	2	0.912	1	0.876	1	0.879
2	Time	0.933	1	0.864	2	0.821	2	0.874
3	Quality	0.787	4	0.816	3	0.766	3	0.788
4	Productivity	0.667	6	0.768	4	0.717	5	0.714
5	Client Satisfaction	0.800	3	0.552	6	0.752	4	0.710
6	Health and safety	0.633	7	0.696	5	0.552	7	0.624
7	Innovation and Learning	0.673	5	0.512	7	0.586	6	0.595

Figure 4.2 Combined RII and rank of Key performance indicators (KPI)



From the table 4.4 shown above, both contractor and consultant ranks cost as a major key performance indicator (KPI) in Road construction projects. Time and Quality also appears in succession as major construction key performance index (KPI) by all three stake holders (Client, Contractor and Consultant).

From the combined result shown on figure 4.2, the key performance index (KPI) which should have been used frequently on the projects are cost, time and quality with a combined RII of 0.879, 0.874 and 0.788 respectively. Following to cost, time and quality; Productivity (0.714), client satisfaction (0.710) and health and safety (0.624) are other key performance indexes that projects should use as per the respondents opinion. The least, but the important key performance index has been innovation and learning (0.595).

The other point evaluated in this section is the opinion of different stakeholders' and their deviation from one another regarding key performance indexes of Road projects. The spearman correlation coefficient is used to quantify the differences of opinions between these parties as shown in the table 4.5 below.

Table 4.5 Spearman correlation coefficient of project performance problems

	Client	Contractor	Consultant
Client	1.00	0.57	0.89
Contractor	0.57	1.00	0.82
Consultant	0.89	0.82	1.00

On table 4.5, the spearman correlation coefficient indicates that there is strong relation between the responses of Client-Consultant, moderate relation between contractor-consultant and weak relation between Client-contractor.

The strong relation between client and consultant indicates that they have the same attitudes and perceptions towards the goal of the project. This is because of most of consultants are the representatives to clients and act as them.

The weak relation of contractor to client implies that contractors have different attitudes and priorities with clients. Clients mostly give priority for the completion of the project as their desire but contractors give more attention for the profitability of the project. As shown it the above table; even if they agree on the top three KPI's (cost, time and quality), there is still big deviation about the importance of the client's satisfaction and productivity.

4.5. Factors Affecting the Performance of Road Construction Projects

In this part, the results of the questionnaire survey are discussed regarding to factors affecting the performance of Road construction projects in Ethiopia. This part of study provides an indication of the participants' and combined relative importance index (RII) and rank of performance related problems in Road construction projects and correlation coefficients between the stake holders.

There are seven main groups that affect the performance of construction projects which discussed earlier in this chapter. Totally sixty one factors were identified from the literatures reviews that affect the performance of construction projects and each are sub-grouped in to the main seven group factors. And the critical factors are discussed below.

The following tables and figures show the summary of participants' and combined relative importance index (RII) and rank of project performance factors according to each target participants and correlations between the participants.

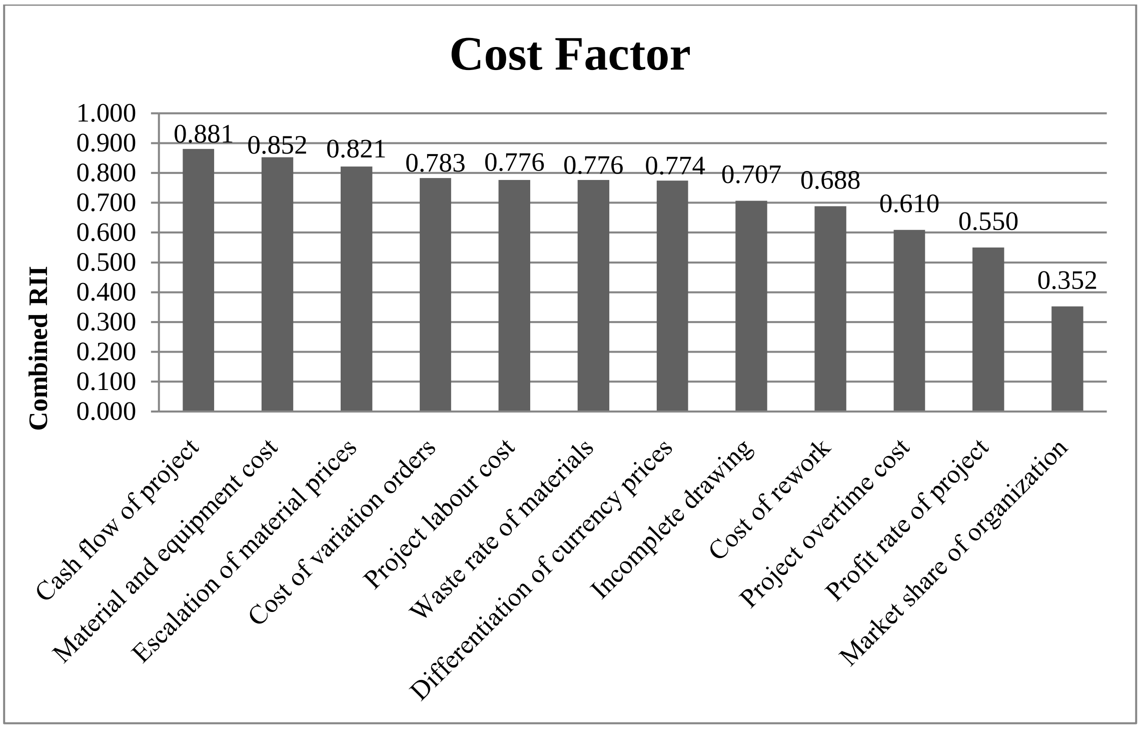
4.5.1. Cost Factors in Road Construction Projects

Twelve factors were identified from the literature reviews that affect the performance of cost. Based on the combined relative importance index (RII) and rank the critical ones on Ethiopian Federal Road construction projects are discussed. Table 4.6 and figure 4.3 show the results of participants' and combined RII and the rank of factors affecting cost performance respectively.

Table 4.6 Participants' RII, combined RII and rank of Cost factors

No.	(1) Cost Factor	Client		Contractor		Consultant		Combined RII
		RII	Rank	RII	Rank	RII	Rank	
1	Market share of organization	0.233	12	0.464	12	0.379	12	0.352
2	Cash flow of project	0.887	1	0.880	2	0.876	1	0.881
3	Profit rate of project	0.353	11	0.800	5	0.538	10	0.550
4	Material and equipment cost	0.860	3	0.896	1	0.807	2	0.852
5	Project labour cost	0.800	7	0.872	3	0.669	7	0.776
6	Project overtime cost	0.693	10	0.664	11	0.476	11	0.610
7	Cost of rework	0.720	9	0.752	7	0.600	8	0.688
8	Cost of variation orders	0.873	2	0.744	9	0.724	5	0.783
9	Waste rate of materials	0.853	5	0.704	10	0.759	4	0.776
10	Escalation of material prices	0.860	3	0.808	4	0.793	3	0.821
11	Differentiation of currency prices	0.840	6	0.752	7	0.724	5	0.774
12	Incomplete drawing	0.753	8	0.784	6	0.593	9	0.707

Figure 4.3 Combined RII and rank of Cost factors



Based on the combined relative important index and rank as shown on figure 4.3, the critical and top ranked factors of cost performance are discussed below.

As shown from the analysis above, Cash flow of a project (0.881); Material and equipment cost (0.852); and Escalation of material prices (0.888) became the critical factors that affect cost performance of a project. Cash flow affects the project budget and project cost performance, because cash flow can give an important evaluation for the cost performance at any stage of project. Materials and equipment's cost affects the liquidity and project cost performance. Escalation of material prices is also the main factor that affects cost performance because it affects the liquidity of projects and cost performance of projects. The cost of construction materials are increases from time to time because of a limited suppliers, factories, shortage of raw materials, shortage of hard currency and cost of transportation from foreign countries.

Variations orders from owners related to design change, increase of material and equipment cost are leads to the increments of project cost. This is due to problem of assumptions during planning stage. Differentiation of currency prices affect profit rate of the project and cost performance. Both clients and Contractors have been suffered from differentiation of currency prices because of economic and political situation of the country.

Waste rate of materials (0.776) and Project labor cost (0.776) have been also the factors which leads to projects not executed on their budgeted cost. If the construction materials which are consumed on site are not properly managed, there will be the occurrence of a large amount of wastes and this leads to cost overrun and it affects the cash flow of the project. Project labor cost also affects the cost performance of project because labor costs are one of the main inputs for project cost.

Table 4.7 Spearman correlation coefficient of Cost factors

	Client	**Contractor**	**Consultant**
Client	1.00	0.50	0.94
Contractor	0.50	1.00	0.62
Consultant	0.94	0.62	1.00

On table 4.7, the spearman correlation coefficient indicates that there is strong relation between the responses of Client-Consultant and weak relation between Client-contractor and contractor-consultant. The strong relation between client and consultant indicates that they have the same attitudes and perceptions towards the factors affecting cost performance of the project. This is because of most of consultants are the representatives to clients and act as them.

The weak relation between Client-contractor and contractor-consultant implies that contractors have too different attitudes and priorities with clients and consultants regarding to factors affecting cost performance of the project.

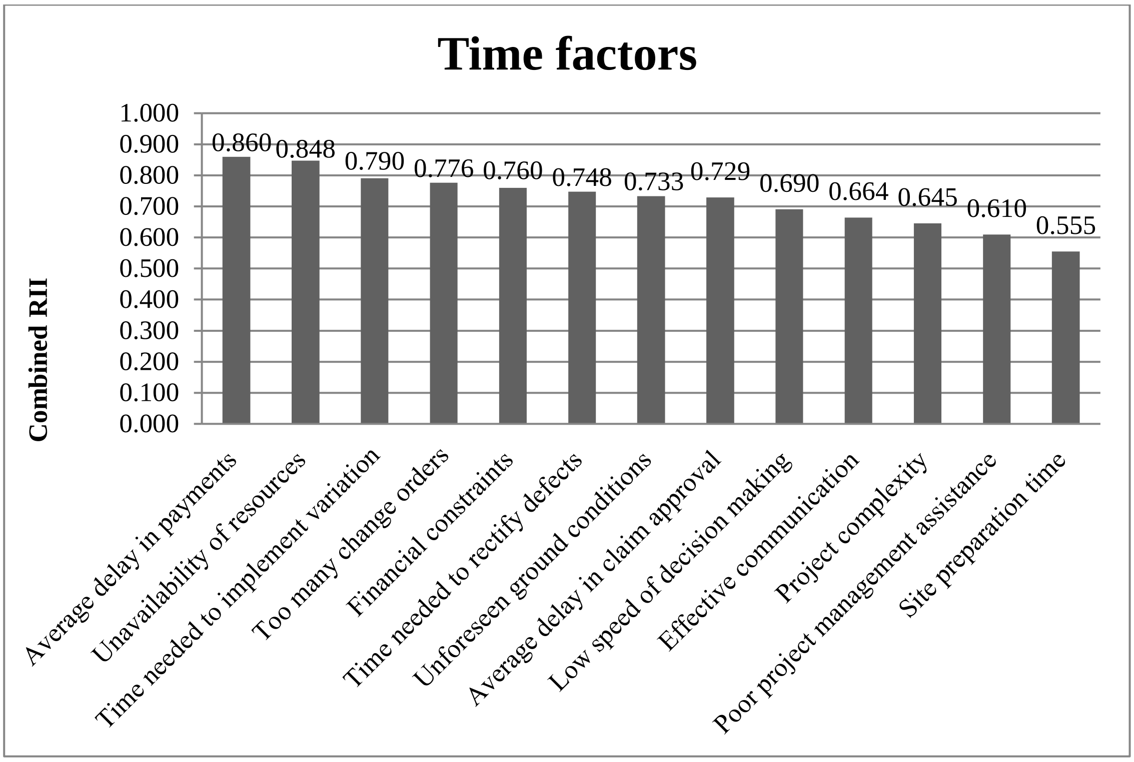
4.5.2. Time Factors in Road Construction Projects

Thirteen factors were identified from the literature reviews that affect time performance. Based on the combined relative importance index (RII) and rank the critical ones on Ethiopian Federal Road construction projects are discussed. Table 4.8 and figure 4.4 show the results of participants' and combined RII and the rank of factors affecting time performance respectively.

Table 4.8 Participants' RII, combined RII and rank of Time factors

No.	(2) Time factors	Client		Contractor		Consultant		Combined RII
		RII	Rank	RII	Rank	RII	Rank	
1	Too many change orders from owner	0.807	3	0.808	5	0.717	7	0.776
2	Poor project management assistance	0.747	7	0.464	13	0.593	12	0.610
3	Unforeseen ground conditions	0.647	12	0.808	5	0.759	4	0.733
4	Low speed of decision making	0.673	11	0.728	7	0.676	8	0.690
5	Project complexity	0.720	9	0.544	12	0.655	11	0.645
6	Effective communication	0.747	7	0.568	11	0.662	9	0.664
7	Financial constraints	0.840	2	0.696	9	0.731	5	0.760
8	Average delay in claim approval	0.700	10	0.840	3	0.662	9	0.729
9	Average delay in payments from owners to contractors	0.793	4	0.936	1	0.862	1	0.860
10	Site preparation time	0.527	13	0.608	10	0.538	13	0.555
11	Unavailability of resources	0.847	1	0.848	2	0.848	2	0.848
12	Time needed to rectify defects	0.787	5	0.720	8	0.731	5	0.748
13	Time needed to implement variation orders	0.773	6	0.832	4	0.772	3	0.790

Figure 4.4 Combined RII and rank of Time factors



Based on the combined RII and rank shown on figure 4.4, the delay in payments from owners to contractors (0.860) directly causes delay in project time. Any payment which needed by the contractor to paid on time, it assures that the contractor to execute the project within the schedule.

Unavailability of resources with RII value of (0.848) has been another critical factor that affects the time performance. If resources are not available as planned through project duration, the project will suffer from problem of time and cost performance. And it also affects the whole performance of projects. This is because resource availability as planned schedule can improve time performance of projects.

Time needed to implement variations (0.790), Too many change orders from owners (0.776), Financial Constraints (0.760) and Time needed to rectify defects (0.748) also have been critical factors of project time performance.

The amount of change orders from owners are directly affects time performance. This is because change orders will interrupt the schedule of the project and sometimes suspend the project due to incomplete design changes which affect the sequence of the project activities. And the time required to implement these variation orders will affect the project time performance. This is because some variations takes or requires more time than the first planned activities. So that the project doer will suffer time and cost performance problems due to the time needed to implement these orders.

The other major factor in time performance is ground conditions. Grounds those have problems, especially unforeseen like poor bearing capacity, black cotton soil and hard rock which are difficult to driven and water table near to the ground affects the time performance of projects.

Table 4.9 Spearman correlation coefficient of Cost factors

	Client	**Contractor**	**Consultant**
Client	1.00	0.29	0.59
Contractor	0.29	1.00	0.77
Consultant	0.59	0.77	1.00

On table 4.9, the spearman correlation coefficient indicates that there is strong relation between the responses of Contractor-Consultant; moderate relation between client-consultant and weak relation between Client-contractor. The strong relation between contractor and consultant indicates that they have the same experience and site exposure towards the factors affecting time performance of the project. The reason behind moderate relation between client-consultant is because of most of consultants are the representatives to clients and act as them.

The weak relation between Client-contractor implies that contractors have too different attitudes and opinions with clients regarding to factors affecting cost performance of the project and both makes the other one responsible for the performance problems and for critical factors that affect time performance of a project

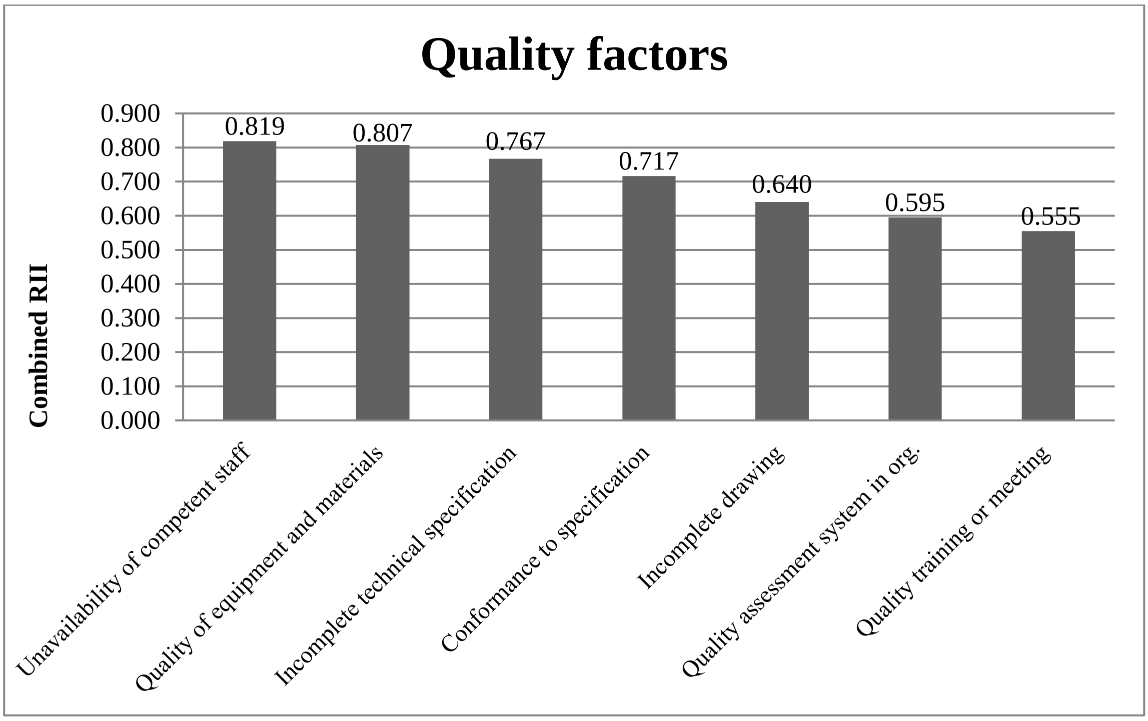
4.5.3. Quality Factors in Road Construction Projects

Seven factors were identified from the literature reviews that affect quality performance. Based on the combined RII and rank the critical ones on Ethiopian Federal Road projects are discussed. Table 4.10 and figure 4.5 show the results of participants' and combined RII and the rank of factors affecting quality performance respectively.

Table 4.10 Participants' RII, combined RII and rank of Quality factors

No.	(3) Quality factors	Client		Contractor		Consultant		Combined RII
		RII	Rank	RII	Rank	RII	Rank	
1	Conformance to specification	0.793	3	0.648	5	0.697	3	0.717
2	Unavailability of competent staff	0.787	4	0.856	2	0.821	2	0.819
3	Quality of equipment or machineries and raw materials	0.853	1	0.696	3	0.855	1	0.807
4	Quality assessment system in organization	0.660	5	0.544	6	0.572	5	0.595
5	Quality training or meeting	0.607	7	0.536	7	0.517	7	0.555
6	Incomplete drawing	0.660	5	0.696	3	0.572	5	0.640
7	Incomplete technical specification	0.800	2	0.880	1	0.634	4	0.767

Figure 4.5 Combined RII and rank of Quality factors



From figure 4.5, unavailability of competent staff with RII of 0.819, quality of equipment or machineries and raw materials (0.807) and incomplete technical specifications (0.767) have been the top three critical factors that affect quality performance of projects.

The materials, equipments and machineries used in any project can affect the quality of the work executed. In Ethiopia most of the available materials are produced by a limited number of producers with a little variation in quality. Most of the equipment being used also has many limitations and some may even surpass their useful life time. The staffs' (labor) that are being available on the market are semi-skilled and un-skilled. These incompetent staffs mainly affect the quality of the project.

Incomplete technical specifications generate challenges to project doers because the purpose of technical specification is to provide adequate information about the type of work to be executed, type of materials, equipment and workmanship to be used. If these factors i.e. type materials, equipment and workmanship are not specified on the contract document, the contractor may use low quality materials equipment and workmanship in order to maximize his profit.

On the same figure, conformance to specification (0.717), incomplete drawings (0.640), Quality assessment system in organization (0.595) and Quality training or meeting (0.555) have been the quality performance factors that ranked from fourth to last by the respondents.

Table 4.11 Spearman correlation coefficient of Quality factors

	Client	**Contractor**	**Consultant**
Client	1.00	0.68	0.86
Contractor	0.68	1.00	0.61
Consultant	0.86	0.61	1.00

On table 4.11, the spearman correlation coefficient indicates that there is strong relation between the responses of Client-Consultant and weak relation between Client-contractor and contractor-consultant. The strong relation between client and consultant indicates that they have the same attitudes and perceptions towards the factors affecting quality performance of the project. This is because of most of consultants are the representatives to clients and act as them.

The weak relation between Client-contractor and contractor-consultant implies that contractors have too different attitudes and priorities with clients and consultants regarding to factors affecting quality performance of the project.

4.5.4. Productivity Factors in Road Construction Projects

Ten factors were identified from the literature reviews that affect productive performance. Based on the combined relative importance index (RII) and rank the critical ones on Ethiopian Federal Road projects are discussed. Table 4.12 and figure 4.6 show the results of participants' and combined RII and the rank of factors affecting productivity of performance respectively.

Table 4.12 Participants' RII, combined RII and rank of Productivity factors

No.	(4) Productivity factors	Client		Contractor		Consultant		Combined
		RII	Rank	RII	Rank	RII	Rank	RII
1	Project size and complexity	0.693	8	0.656	9	0.683	8	0.679
2	Management-labour relationship	0.673	9	0.688	7	0.634	10	0.664
3	Absenteeism rate through project (late start and early exists)	0.787	4	0.768	3	0.759	3	0.771
4	Number of new projects per year	0.667	10	0.6	10	0.648	9	0.640
5	Sequencing of work according to schedule	0.833	2	0.864	1	0.821	1	0.838
6	Local cultural characteristics	0.713	7	0.72	5	0.703	6	0.712
7	Non-working holidays	0.8	3	0.8	2	0.786	2	0.795
8	Local climate conditions	0.72	6	0.72	5	0.71	5	0.717
9	Employees motivation	0.787	4	0.664	8	0.724	4	0.729
10	Employees attitudes	0.84	1	0.752	4	0.697	7	0.764

Figure 4.6 Combined RII and rank of Productivity factors

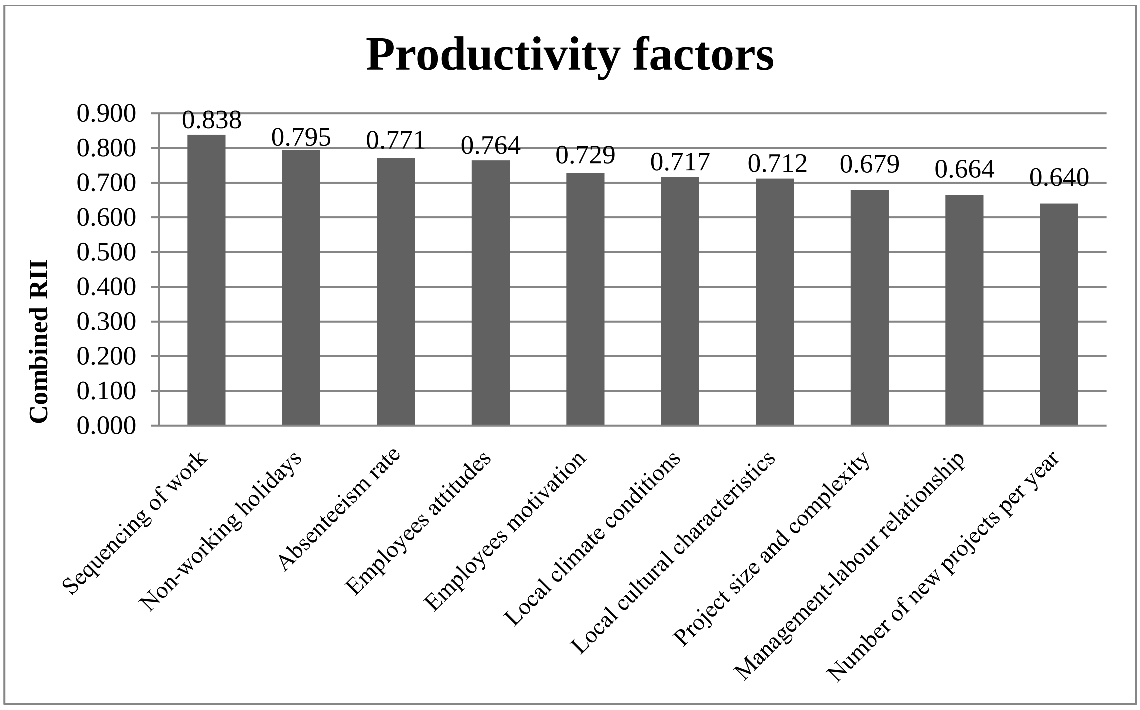


Figure 4.6 shows that, Sequencing of work according to schedule (0.838), Non-working holidays (0.795), and absenteeism rate through project (0.771) have been the top and the critical factors that affect the performance of productivity.

Non-working holidays through the year greatly affects the productivity rate of a project. These non-working holiday that wasn't considered during project schedule preparation (like religious or cultural holidays that calendar doesn't recognize) highly disturb the normal productivity of a project. Absenteeism rate through the project will also affect the productivity performance of project. Therefore, the project will suffer from delay due to these late entries and early exits of labors from the site.

Employee's attitude (0.764), employee's motivation (0.729), Local climate conditions (0.717), and local cultural characteristics (0.712) also have been the critical factors that affect performance productivity. The changes in local climate through the year greatly affect the productivity rate of a project. On the months of high rain intensity the productivity of most construction projects greatly affected because the rain will cause unsuitable working conditions for labour and machineries on the project site. The characteristics of local cultures also has been put its effect on the project. This is due to the applicable norms of the community on the area of the project being executed. Employee's motivation is another critical factor that highly wobbles productivity of the project. If the contractor keeps his employees moral high; the productivity of the activities increases and vice versa.

Table 4.13 Spearman correlation coefficient of Productivity factors

	Client	**Contractor**	**Consultant**
Client	1.00	0.77	0.74
Contractor	0.77	1.00	0.78
Consultant	0.74	0.78	1.00

On table 4.13, the spearman correlation coefficient indicates that there is moderate relation between the responses of Client-Consultant, Client-contractor and contractor-consultant. The moderate relation between client and consultant indicates that they have the same attitudes and perceptions towards the factors affecting performance productivity of the project. This is because of most of consultants are the representatives to clients and act as them.

4.5.5. Client Satisfaction Factors in Road Construction Projects

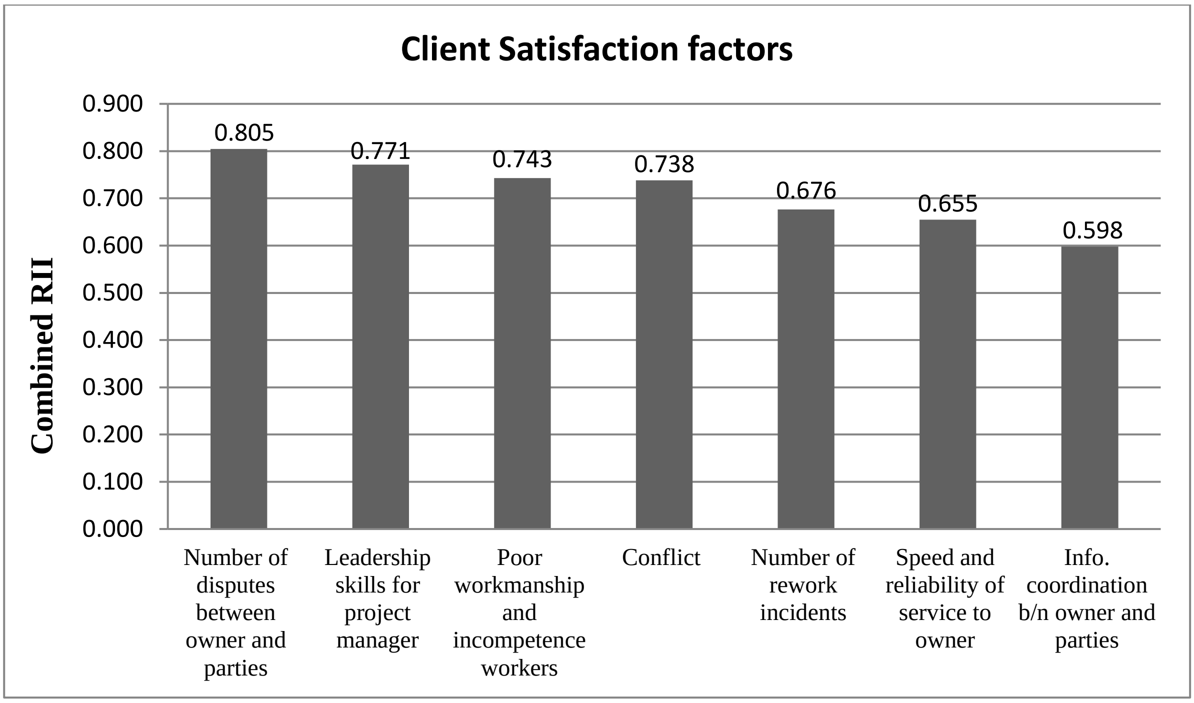
Seven factors were identified from the literature reviews that affect Client Satisfaction performance. Based on the combined relative importance index (RII) and rank the critical ones on Ethiopian Federal Road projects are discussed. Table 4.14 and figure 4.7 show the results of participants' and combined RII and the rank of factors affecting Client Satisfaction performance respectively.

Table 4.14 Participants' RII, combined RII and rank of Client Satisfaction factors

No.		**Client**	**Contractor**	**Consultant**	

	(5) Client Satisfaction factors	RII	Rank	RII	Rank	RII	Rank	Combined RII
1	Leadership skills for project manager	0.833	2	0.672	5	0.793	1	0.771
2	Number of disputes between owner and project parties	0.847	1	0.776	2	0.786	2	0.805
3	Speed and reliability of service to owner	0.807	4	0.592	7	0.552	6	0.655
4	Number of rework incidents	0.653	7	0.792	1	0.6	5	0.676
5	Information coordination between owner and project parties	0.687	6	0.608	6	0.497	7	0.598
6	Conflict	0.793	5	0.68	4	0.731	3	0.738
7	Poor workmanship and incompetence workers	0.827	3	0.704	3	0.69	4	0.743

Figure 4.7 Combined RII and rank of Client Satisfaction factors



As shown on the figure 4.7, number of disputes between owner and project parties has been the first rank and the critical factor which affects the performance of client satisfaction with RII having 0.805. Disputes between owner and contractor and owner and consultants will affect the relationship between them and the degree of client satisfaction will be affected.

Leadership skill of project manager (0.771), Poor workmanship and incompetence workers (0.743) and conflict (0.738) have been the second to fourth critical client satisfaction performance factors next to number of disputes between owner and project parties.

Leadership skill for project manager is the most important one because leadership skills for project manager affect the construction project performance. It is significant and important for effectiveness of project performance because client satisfaction depends up on it. It also assists to supervise the project with strong and suitable performance.

The existence of poor workmanship and incompetent staff on the project site will greatly affect the client satisfaction. This is an important factor of client satisfaction because it affects the quality of the project and service life of the project. Conflicts between contractors to labors and labors themselves on the project site will greatly affect the degree of clients' satisfaction. This is because any unnecessary conflict on the project may cause death or injuries.

Table 4.15 Spearman correlation coefficient of Client satisfaction factors

	Client	**Contractor**	**Consultant**
Client	1.00	0.00	0.71
Contractor	0.00	1.00	0.36
Consultant	0.71	0.36	1.00

On table 4.15, the spearman correlation coefficient indicates that there is strong relation between the responses of Client and Consultant due to the comparable similarity of their priorities towards the project goal and factors affecting client satisfaction performance of the construction project. This is because of most of consultants are the representatives to clients and act as them. It's also shown that there is a weak relation between Client-contractor and contractor-consultant.

The weak relation between Client-contractor and contractor-consultant implies that contractors have very different approaches and priorities with clients and consultants regarding to factors affecting client satisfaction performance of the project.

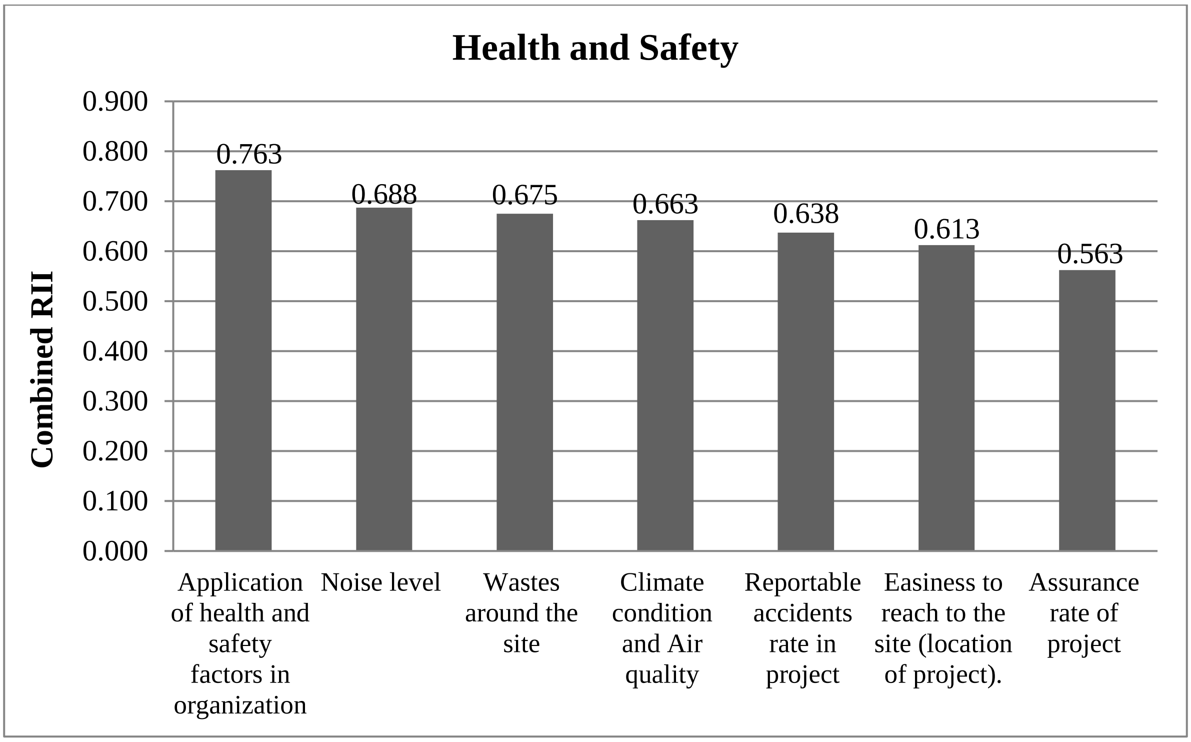
4.5.6. Health and Safety Factors in Road Construction Projects

Seven factors were identified from the literature reviews that affect Health and Safety performance. Based on the combined relative importance index (RII) and rank the critical ones on Ethiopian Federal Road projects are discussed. Table 4.16 and figure 4.8 show the results of participants' and combined RII and the rank of factors affecting Health and Safety performance respectively.

Table 4.16 Participants' RII, combined RII and rank of Client Satisfaction factors

No.	(6)Health and Safety	Client		Contractor		Consultant		Combined RII
		RII	Rank	RII	Rank	RII	Rank	
1	Reportable accidents rate in project	0.5333	5	0.6333	4	0.6857	4	0.6375
2	Application of health and safety factors in organization	0.8	1	0.7667	1	0.7429	1	0.7625
3	Assurance rate of project	0.4667	7	0.5667	7	0.6	6	0.5625
4	Easiness to reach to the site (location of project).	0.6	4	0.6667	3	0.5714	7	0.6125
5	Wastes around the site	0.7333	2	0.6	6	0.7143	3	0.675
6	Climate condition and Air quality	0.5333	5	0.7667	1	0.6286	5	0.6625
7	Noise level	0.6667	3	0.6333	4	0.7429	1	0.6875

Figure 4.8 Combined RII and rank of Health and Safety factors



As shown on the figure 4.8, application of health and safety factors in organization (0.763) and noise level (0.688) has been the critical and top rank health and safety performance factors.

The application of health and safety factors on projects will decrease the occurrence problems related to health and safety and it will improve the awareness of the workers. This factor affects strongly on performance of projects because it affects the safety system in projects. The noise level of equipment and machineries on the site will directly affects the health of workers, especially workers working with near the equipment and machineries. When the level of noises high, it will decreases the level of communications between workers and this will affect the productivity on the site; because communications between workers will greatly affect the productivity of them.

Waste around the site (0.675), climate condition and air quality (0.663) and reportable accidents rate in project (0.638) have been other critical factors affecting the performance of health and safety. Waste around the site should organize properly otherwise it will cause accidents to labours and create uncomfortable environment in site that results in a decreased productivity. The air quality with in and around the site will greatly affect productivity of the labors; this is because it affects their health and safety of the labors. Reportable accidents rate in project is related to the number of occurrence of injuries and illness on the employees. This factor is the critical one because reportable accidents rate usually affects the safety performance and the client and satisfaction in projects.

Table 4.17 Spearman correlation coefficient of Health and Safety factors

	Client	**Contractor**	**Consultant**
Client	1.00	0.38	0.71
Contractor	0.38	1.00	0.09
Consultant	0.71	0.09	1.00

On table 4.17, the spearman correlation coefficient indicates that there is strong relation between the responses of Client-Consultant and weak relation between Client-contractor and contractor-consultant. The strong relation between client and consultant indicates that they have the same attitudes and perceptions towards the factors affecting Health and Safety performance of the construction project. This is because of most of consultants are the representatives to clients and act as them.

The weak relation between Client-contractor and contractor-consultant implies that contractors have very different attitudes and priorities with clients and consultants regarding to factors affecting Health and Safety performance of the project.

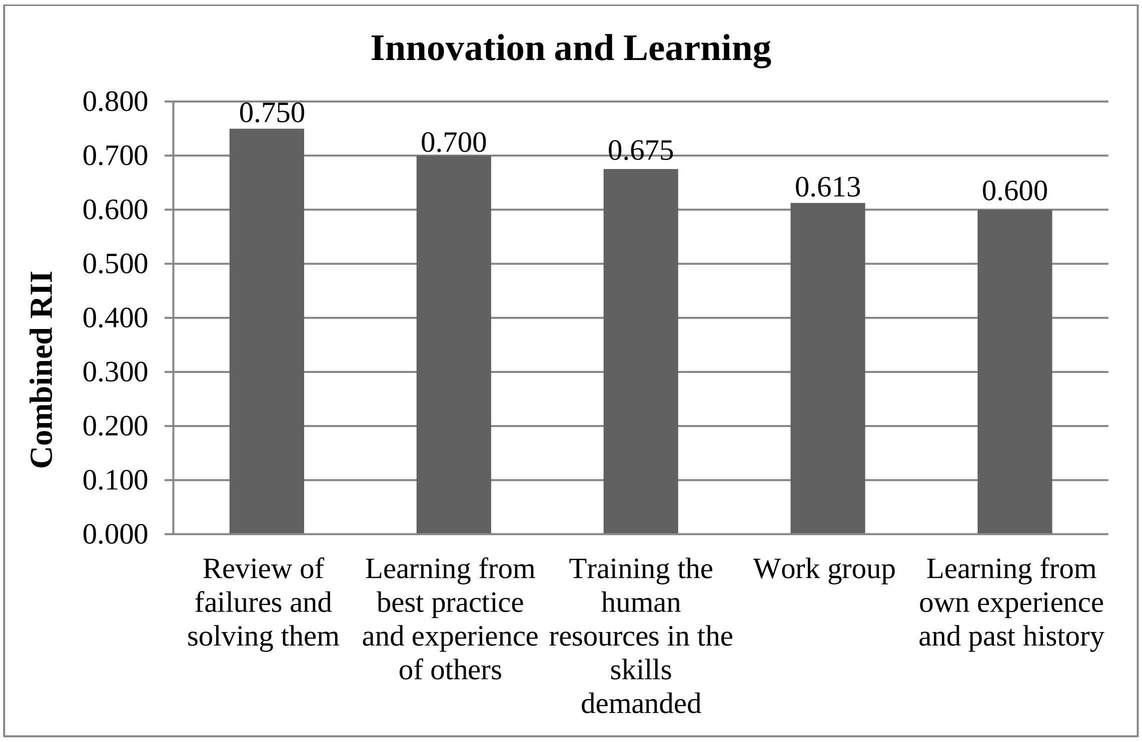
4.5.7. Innovation and Learning Factors in Road Construction Projects

Five factors were identified from the literature reviews that affect Innovation and Learning performance. Based on the combined relative importance index (RII) and rank the critical ones on Ethiopian Federal Road projects are discussed. Table 4.18 and figure 4.9 show the results of participants' and combined RII and the rank of factors affecting Innovation and Learning performance respectively.

Table 4.18 Participants' RII, combined RII and rank of Innovation and Learning factors

No.	(7) Innovation and Learning	Client		Contractor		Consultant		Combined RII
		RII	Rank	RII	Rank	RII	Rank	
1	Learning from own experience and past history	0.600	4	0.633	4	0.571	5	0.600
2	Learning from best practice and experience of others	0.667	2	0.700	2	0.714	2	0.700
3	Review of failures and solving them	0.733	1	0.733	1	0.771	1	0.750
4	Work group	0.533	5	0.600	5	0.657	4	0.613
5	Training the human resources in the skills demanded by the project	0.667	2	0.667	3	0.686	3	0.675

Figure 4.9 Combined RII and rank of Innovation and Learning factors



Based on figure 4.9, review of failures and solving them with RII of 0.750 have been first and the critical factor which affects the innovation and learning performance of a project. Once failures occurred in a project, reviewing, solving and protecting them before happen again will improve the cost, time and quality of project performance. This factor also will enhance project performance and will satisfy the project stakeholders.

Learning from best practice and experience of others (0.700) has been the second critical factor that affects innovation and learning performance project. Learning from best practice and experience of others will improve performance of projects. It can also improve and develop the performance of current and future projects. Taking the practice and experience of best organizations will make others organizations to minimize risks related to safety, health, time, cost and quality performance of projects.

As shown on the same figure, training the human resources in the skills demanded by the project (0.675) has been the third critical learning and innovation performance factor of the projects. Training the human resources in the skills demanded by the project assists employees to perform the project effectively and successfully. This is an important learning and innovation factor because it improves the productivity performance of a project.

Table 4.19 Spearman correlation coefficient of Health and Safety factors

	Client	**Contractor**	**Consultant**
Client	1.00	0.95	0.85
Contractor	0.95	1.00	0.90
Consultant	0.85	0.90	1.00

On table 4.19, the spearman correlation coefficient indicates that there is strong relation between all stakeholders' responses. The strong relation between client-consultant, Client-contractor and contractor-consultant indicates that they have the same attitudes and perceptions towards the factors affecting learning and innovation performance of the construction project.

All stakeholders agreed that review of failures and solving them should be a prior factor that affects the learning and innovation performance of a construction project. Learning from best practice and experience of others and Training the human resources in the skills demanded by the project are also included in the top three factors that affect learning and innovation performance of a project by all three parties.

4.6. The Critical Factors that Affects Project Performance

Based on the literatures reviews and as it was stated earlier in this chapter, there were sixty one factors that affects the performance of construction projects that sub-grouped in seven major groups. From the analysis and discussions made above, factors affecting project performance in Ethiopian Federal Road construction projects ranked based on their RII values. Factors with RII value of 0.8 or higher are selected as critical factors since RII ≥ 0.8 implies that the impact of the factor to project performance is either high or very high (as per the ordinary scale shown in Table 3.2) As indicated in Table 4.20, the most important factors affecting project performance were identified and presented as follows.

Table 4.20 Critical factors that affect project performance

Rank	**Factors Affecting Project Performance**	**Combined RII**	**Group**
1	Cash flow of project	0.881	Cost
2	Average delay in payments from owners to contractors	0.860	Time
3	Material and equipment cost	0.852	Cost
4	Unavailability of resources	0.848	Time
5	Sequencing of work according to schedule	0.838	Productivity
6	Escalation of material prices	0.821	Cost
7	Unavailability of competent staff	0.819	Quality
8	Quality of equipment or machineries and raw materials	0.807	Quality
9	Number of disputes between owner and project parties	0.805	Client Satisfaction

After finding the most significant factors affecting construction performances of road projects, a second questionnaire was drafted to collect tangible data from different construction projects. All ongoing Federal road projects were used again for the second questionnaire.

According to William (2008) the set of calibration projects is used to complete the statistical regression analysis while the validation project set is used to validate the model and ensure that the model prepared reflect reality. Eighty percent (80%) of the collected data can be used for developing the model while the remaining twenty percent (20%) can be used for validating the model (William, 2008).

Therefore, for this research the number of projects used for model development and model validation are calculated based on the ratio given by William (2008). Table 4.21 shows the sample size used for model calibration and model validation purpose. The sample size has been divided in to two sets, i.e., projects for model formation/training data set and projects for validation/testing data set.

Table 4.21 Sample size used for the study

Project type	Sample size	No. of projects used for Model Calibration	No. of projects used for Model validation
Building construction projects	**35**	28	7

4.7. Principal Component Analysis

4.7.1. Testing for the Appropriateness of Using PCA

As discussed in the data analysis section of this paper, checking the appropriateness of using PCA is the first step in principal component analysis method. From Table 4.22, the KMO had a value of 0.801, which is greater than 0.5, therefore, KMO values greater than 0.5 are considered as acceptable, which also indicates that the sampling adequacy for this study was good. Also, as shown in the table, the Bartlett's test was highly significant ($p < 0.05$), indicating that the original correlation matrix was not an identity matrix. Both tests therefore confirmed that performing PCA on the quantitative project scope factors was appropriate.

Table 4.22 KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.801**
Bartlett's Test of Sphericity	Approx. Chi-Square	196.232
	Df	36
	Sig.	**.000**

4.7.2. Extracting Principal Components

PCA extracts from a set of p variables, a reduced set of m principal components that account for most of the variance in the p variables (Yang, 2012). The eigenvalues associated with each factor in the set of ***p*** variables as well as the scree plot, is usually used as a guide to determine the reduced set of ***m*** principal components or factors that account for most of the variance in the set of ***p*** variables.

Table 4.23 shows the eigenvalues associated with each linear component before extraction, after extraction and after rotation and the scree plot, Figure 4.10 shows a plot of the eigenvalues against the linear components. The eigenvalue associated with each linear component represent the variance explained by that linear component and as recommended by (Field, 2005), only eigenvalues greater than **one** are considered when extracting the principal components.

As shown in Table 4.23 Nine linear components/variables were generated for the study because nine variables were factored out using RII and considered in the analysis.

However, looking through the eigenvalues associated with each linear component, it can be seen that there are four linear components with eigenvalues greater than one. Therefore, there will be four principal components as shown in the column labeled extraction sum of squared loadings. From Table 4.23 also, the total variance explained/accounted for by the extracted principal components, was **71.252%,** indicating that some small amount of information (28%) was lost in the process and therefore good results will still be obtained when these principal components are used, instead of the whole data set.

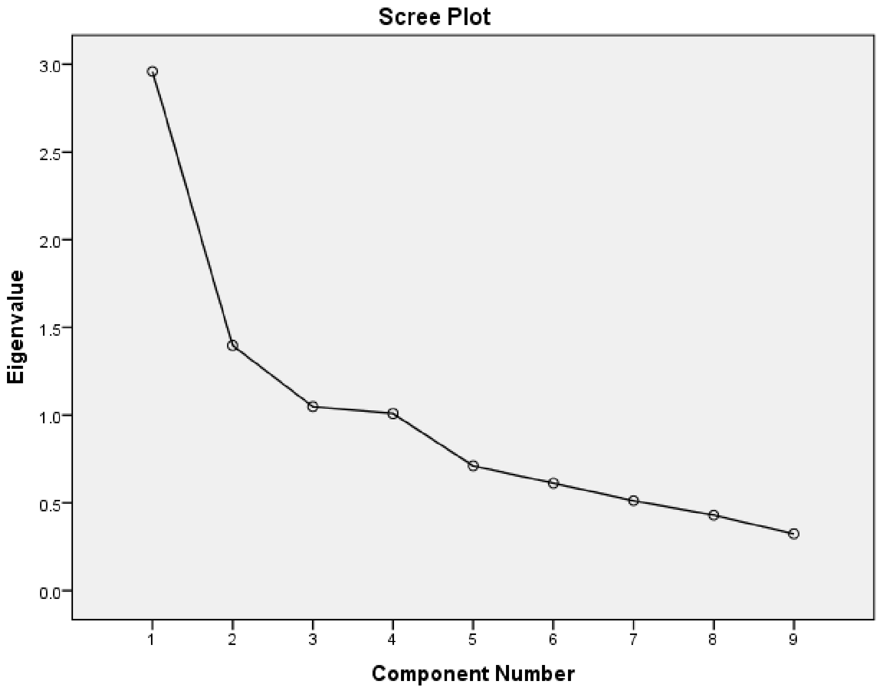
The first principal component accounted for the highest variance (32.879%), followed by the second component (15.52%), and the third and fourth components having variance of (11.643%) and (11.210%) respectively. This was however not the case in the column labeled rotation sums of squared loadings, as rotation in PCA is meant to equalize the relative importance of each principal component.

Table 4.23 Extraction of principal components

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	**2.959**	32.879	32.879	2.959	32.879	32.879	2.802	31.132	31.132
2	**1.397**	15.520	48.399	1.397	15.520	48.399	1.336	14.843	45.975
3	**1.048**	11.643	60.042	1.048	11.643	60.042	1.139	12.658	58.633
4	**1.009**	11.210	**71.252**	1.009	11.210	71.252	1.136	12.619	**71.252**
5	.711	7.895	79.147						
6	.612	6.801	85.948						
7	.512	5.688	91.636						
8	.430	4.776	96.412						
9	.323	3.588	100.000						
Extraction Method: Principal Component Analysis.									

Figure 4.10 shows the scree plot. In the scree plot, the point of inflection at which the plot begins to tail off, signifies the point at which the linear components with eigenvalues greater than 1 terminates (Field, 2005). Taking a close look at this plot, four principal components were indicated by the scree plot, with eigenvalues greater than one.

Figure 4.10 Scree plot



4.7.3. Selecting the Principal Components

The principal corresponding components need to be selected in order to be able to use the extracted principal components in a multiple linear regression. The criterion for selection used by Dascalu & Cozma (2008) was adopted for this study. The criterion involves selecting the predictor/linear component with the biggest correlation coefficient in the rotated component matrix. Table 4.24 shows the rotated component matrix for the principal components extracted in Table 4.23. It shows the factor loadings of each variable/linear component into the extracted principal components.

Factor loading refers to the correlation coefficient between each variable/linear component and a principal component. As shown in Table 4.24, each variable/linear component is loaded differently into the respective principal components. This clearly indicates that while the correlation coefficient/factor loading of a linear component/variable may be highly significant in one of the principal components, it may not be significant in the other principal components and hence, its correlation coefficient/factor loading is absent /omitted in such principal components.

Table 4.24 Rotated component matrix

Rotated Component Matrix[a]				
	Component			
	1	2	3	4
Dispute b/n Client and parties	-.619	-.688	-.072	-.072
Cash flow Problem	-.565	**-.868**	.043	.013
Material Price Escalation	.841	.404	-.065	-.031
Material and Equipment Cost Percentage	.697	.655	-.045	-.079
Sequencing Practice according to schedule	.088	.034	-.025	**.970**
Resource Availability	-.013	.106	**.981**	-.028
Available manpower skill	.840	.209	.183	.173
Available Equipment Quality	.239	.807	.270	.221
Delay in payments	**-.849**	-.331	.114	-.168
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.				

Based on the selection criterion stated by Dascalu & Cozma (2008), it can be seen from Table 4.24 that the variables/linear components with the highest correlation coefficient with the principal components are; Delay in payments, Cash flow Problem, Resource Availability and Sequencing Practice according to schedule. Table 4.25 shows the extracted four components and their respective rotated component matrix values.

Table 4.25 Selected principal components

No	Principal corresponding component/Linear components	Factor loading/correlation coefficient
1	Delay in payments	**-.849**
2	Cash flow Problem	**-.868**
3	Resource Availability	**.981**
4	Sequencing Practice according to schedule	**.970**

The selected linear components/variables as shown in Table 4.25 above are therefore considered as the most significant predictors/variables to estimate construction performance of Road construction projects located in the selected areas. The regression model to estimate construction Performance will then be developed by using multiple linear regression (MLR) analysis using the selected linear components/variables.

4.8. Multiple Linear Regression (MLR) Analysis

Based on an assumption that a multiple linear relationship exists between construction performance and a combination of independent variables, a multiple linear regression (MLR) analysis was performed. MLR analysis was conducted using construction performance as the dependent/response variable and the four independent variables; Delay in payments, Cash flow Problem, Resource Availability and Sequencing Practice according to schedule. The result of the multiple linear regression analysis which was performed using a forward selection procedure at a significance level of 5% is discussed as follows.

4.8.1. Multiple Linear Regression Results

The following section presents the results of the multiple regression analysis. As shown in Table 4.26, Enter method was deployed and the following results below were found.

Table 4.26 Selected principal components

Model Summary[b]									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.921[a]	.849	.822	15.29615	.849	32.233	4	23	.000
a. Predictors: (Constant), Sequencing Practice according to schedule, Resource Availability, Cash flow Problem, Delay in payments									
b. Dependent Variable: Performance									

Based on the selected four factors stated above, the ability of the developed model to predict construction performance of a road construction was found to be about **84.90%.**

Table 4.27 ANOVA results of regression analysis

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	30166.247	4	7541.562	32.233	.000[b]
	Residual	5381.363	23	233.972		
	Total	35547.611	27			
a. Dependent Variable: Performance						
b. Predictors: (Constant), Sequencing Practice according to schedule, Resource Availability, Cash flow Problem, Delay in payments						

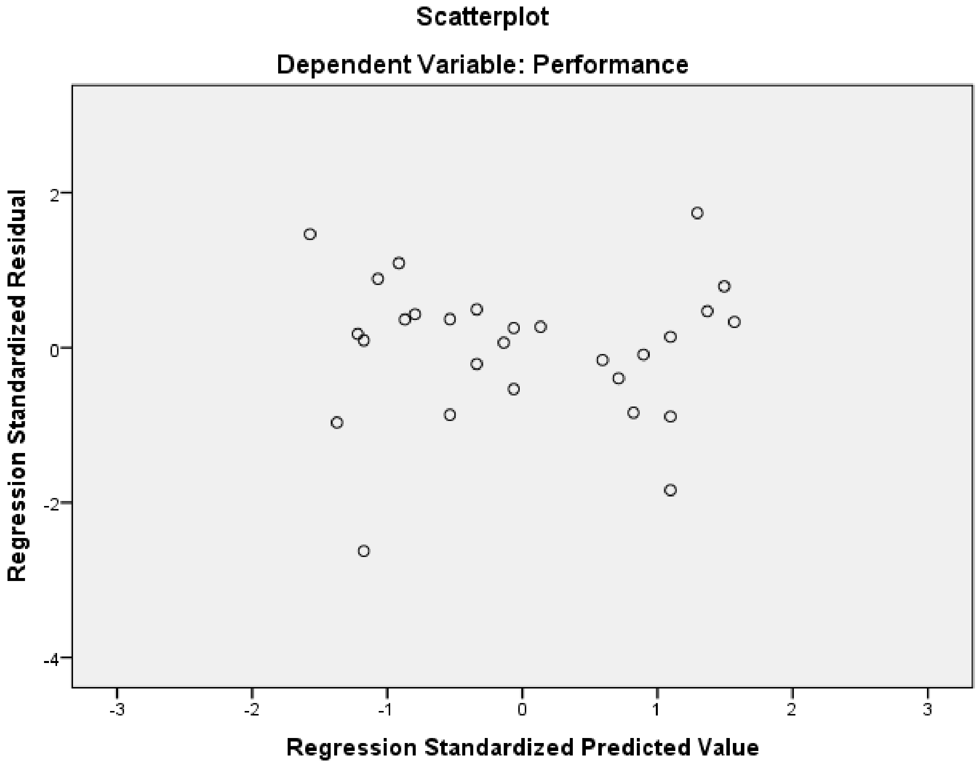
- **Checking for Outliers:**

- Outliers are checked by using the Mahalonobis distance, where the maximum Mahalanobis distance should be less than the critical chi-square value. The critical chi-square value for a model with two independent variables at a significance level of **0.000** is greater than **18.467** (see Appendix 4).
- The maximum Mahalanobis distance as shown in Table 4.28 was **10.171**, which is less than the critical chi-square value (11.667), indicating there is no outlier in the data set. Therefore, since there is no outlier found in the data it is safe to say that the first assumption of regression analysis is met.

Table 4.28 Residual statistics

Residuals Statistics[a]					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	30.2554	135.2244	82.7961	33.42557	28
Std. Predicted Value	-1.572	1.569	.000	1.000	28
Standard Error of Predicted Value	3.127	10.812	6.273	1.588	28
Adjusted Predicted Value	26.7930	133.8533	82.7041	33.50962	28
Residual	-40.17123	26.58458	.00000	14.11771	28
Std. Residual	-2.626	1.738	.000	.923	28
Stud. Residual	-2.952	1.881	.003	1.016	28
Deleted Residual	-50.74586	31.14252	.09194	17.15267	28
Stud. Deleted Residual	-3.663	2.000	-.022	1.117	28
Mahal. Distance	.164	**12.526**	3.857	2.502	28
Cook's Distance	.000	.459	.043	.088	28
Centered Leverage Value	.006	.464	.143	.093	28
a. Dependent Variable: Performance					

Figure 4.11 Scatter plot



- **Checking for Linearity:**

In the scatter plot diagram as shown in Figure 4.11 most of the scores are clustered in the center and form roughly a rectangular distribution, therefore this indicates that the assumption of linearity is met for the fitted model.

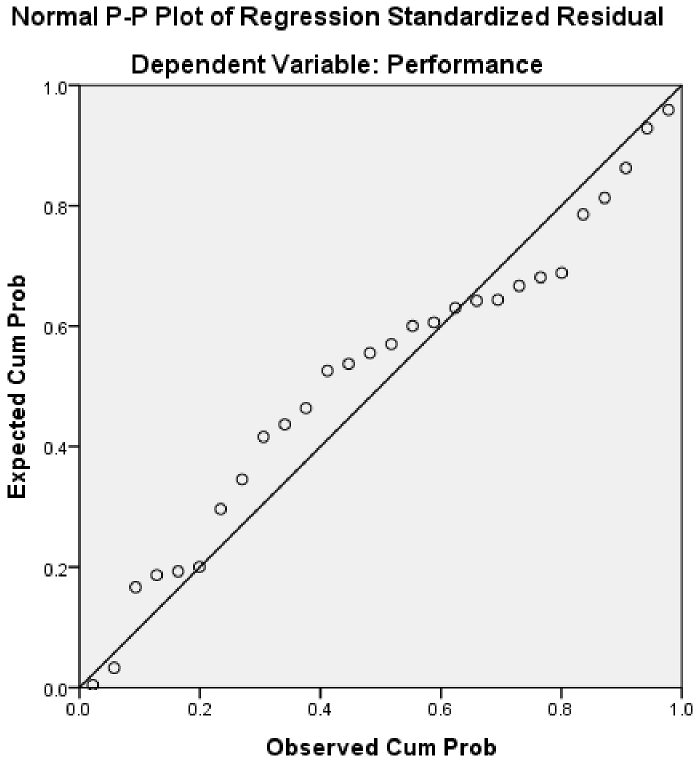
- **Checking for Multicollinearity**:

From the results of MLR analysis, it was found that the model has got a variance inflation factor (VIF) value which is in b/n 1-10, and tolerance value which is greater than 0.1. Hence, as per the results shown in Table 4.29, there is no problem of multicollinearity in the model.

- **Checking for Normality:**

In the normal probability plot as shown in Figure 4.12, all points lie reasonably closer to the line therefore, the normality assumption is met.

Figure 4.12 Normal probability plot



4.8.2. Model Formulation

Based on the results of MLR analysis, the model for estimating construction performance is written by using the unstandardized coefficients of regression given **in Table 4.29** as;

- **C.P = 117.140 - 1.332 (D.P) - 10.145 (C.F.P) + 15.315 (R.A) + 2.481 (S.P)**

Where: C.**P** is construction Performance in Percentage

D.P is Delay in payments in days.

C.F.P is Cash flow Problem given by ordinal representation of occurrence of cash flow shortage (1, 2, 3, 4 & 5).

R.A is Resource Availability given by nominal representation of (1, 2 & 3).

S.P is Sequencing Practice according to schedule given by nominal representation of (1, 2, 3, 4 & 5).

Since the method selected is Enter method, SPSS starts with all of the selected independent variables included in the model, then determines the dependent variable.

Table 4.29 Regression coefficients of fitted model

Coefficients[a]										
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	**117.140**	44.529		2.631	.015	25.024	209.255		
	Delay in payments	**-1.332**	.659	-.367	-2.021	.055	-2.695	.031	.199	5.014
	Cash flow Problem	**-10.145**	6.531	-.233	-1.553	.134	-23.65	3.365	.294	3.405
	Resource Availability	**15.315**	6.349	.332	2.412	.024	2.180	28.449	.348	2.874
	Sequencing Practice according to schedule	**2.481**	6.007	.069	.413	.683	-9.944	14.907	.234	4.274
a. Dependent Variable: Performance										

4.9. Model Validation

The ability of the developed model to predict construction performance of road construction projects was found to be about 84.90%. The independent variables in the model are strongly associated with each other that they are essentially measuring the same thing, construction Performance. The developed model of construction Performance for road projects in selected federal road projects was tested and validated by comparing the observed actual estimates from ERA and the model predictions for validation projects which were not used in the modeling process i.e., 20% of the data set which was set aside during the modeling process as shown in Table 4.30. The performance of the proposed model was also evaluated by checking the value of a statistical parameter; mean absolute percentage error (MAPE). The developed construction performance model showed a relatively minimum **MAPE, 2.98%.**

Table 4.30 Model's prediction and actual performance

Model: C.P = 117.140 - 1.332 (D.P) - 10.145 (C.F.P) + 15.315 (R.A) + 2.481 (S.P)							
Predicted Performance (%)	Actual Performance from ERA (%)	Delay in payments	Cash flow Problem	Resource Availability	Sequencing Practice according to schedule	PE	APE
52.23	52.92	45	4	2	2	-1.308	1.31
68.02	66.15	35	4	2	3	2.834	2.83
84.83	88.38	30	3	2	3	-4.019	4.02
39.39	43.90	45	4	1	3	-10.263	10.26
62.37	63.43	45	3	2	2	-1.666	1.67
119.43	118.74	25	2	3	4	0.579	0.58
64.85	64.74	45	3	2	3	0.177	0.18
						MAPE	**2.98 %**

4.10. Summary of Results

The main objective of this research was to develop a model which can be used to estimate construction performance of road construction projects. The research was done in projects located in Central region categorized by Ethiopian road Authority (ERA), where the model will be used to estimate construction performance for contractors and consultants at any stage in a reliable and practical way by using quantitative project scope variables.

A detailed literature review was done to find out factors affecting construction performance in road construction projects. Sixty one factors were then used in the questionnaire distributed aiming to select most significant factors affecting performance. RII methods was used in selecting most significant factors, factors with RII value of 0.8

or higher are selected as critical factors since RII ≥ 0.8 indicates that the impact of the factor to project performance is either high or very high. There were 9 factors having RII > 0.80 (Note that selecting the top nine factors does not mean that rest of the factors are not significant or have no impact on construction performance. All 61 factors have an impact on Construction performance; the difference is in the magnitude of their impact). Those factors were then used in a second questionnaire aiming to collect tangible data from different construction projects located in the selected region. After data collection is done the collected data were subjected to principal component analysis method to factor out the principal factors affecting construction performance. Principal component analysis selects four major factors based on their Eigen values.

It was found that the most significant predictive quantitative project scope variables for estimating construction performance of road construction are Delay in payments, Cash flow Problem, Resource Availability and Sequencing Practice according to schedule; where the larger portion of the variability in construction performance is explained by the Resource Availability (R.A). The model was found to be capable of predicting construction performance measured by its coefficient of determination. Therefore, the developed model for estimating construction performance of road projects in Central region, Ethiopia, is given by the following relationship.

- **C.P = 117.140 - 1.332 (D.P) - 10.145 (C.F.P) + 15.315 (R.A) + 2.481 (S.P)**

Where: C.**P** is construction Performance in Percentage

D.P is Delay in payments in days.

C.F.P is Cash flow Problem (measured in ordinal scale),

R.A is Resource Availability (measured in ordinal scale),

S.P is Sequencing Practice according to schedule (measured in ordinal scale),

5. CONCLUSIONS & RECOMMENDATIONS

5.1. Conclusions

The main aim of this research is to develop a multi-variate regression model to predict construction performance for road construction projects, at early and later stage of construction projects in Federal road projects. Multi-variate regression model developed was able to achieve the objectives of this research. The following is the most important conclusion drawn from the research:

1- Based on literatures 61 factors affecting construction performance were identified, and grouped into 8 groups of Cost, Time, Quality, Productivity, Client Satisfaction, Health and safety, Innovation and Learning factors.

   The most effective factors that affect construction performance of road construction projects were identified from analysis of 83 questionnaires. By using RII as a tool to select factors having the most impact, the researcher decided to select factors having RII value greater than 0.80. Nine key factors were adopted as most effective factors affecting construction performance; which are, Material Price Escalation, Material and Equipment Cost Percentage, Delay in payments, Cash flow Problem, Resource Availability, Available manpower skill, Available Equipment Quality, Sequencing Practice according to schedule, Dispute b/n Client and parties. From these nine factors four were factored out using principal component analysis which is a factor reduction method. These four factors are Delay in payments, Cash flow Problem, Resource Availability and Sequencing Practice according to schedule.

2- Tangible Data of road construction projects were collected from second questionnaire. The selected projects were the ones which were still under construction at the time of data inquiry. Besides filling of the questionnaires by resident engineers and project managers, direct observation was executed to grasp the authenticity of the data. 35 collected pieces of data were divided randomly into two sets, as training set (28 sets of data 80%), and testing set (7 sets of data 20%).
3- Developing a Multi-variate regression model passed through several steps started with selecting the application to be used in building the model. SPSS 21 program was selected for its efficiency in several previous researches in addition to its ease of use and extract results. The data sets were encoded and entered into MS excel spreadsheet to start training process for different models, then transported to SPSS spreadsheet for model development.
4- The accuracy performance of the adopted model recorded is 84.90%, where the model performed well and no significant difference was discerned between the estimated output and the actual productivity value.

5- In order to ensure the validity of the model in estimating the performance of new projects, many statistical performance measures were conducted i.e.; Absolute Percentage Error (APE), Total Mean Absolute Percentage Error (Total MAPE), and Correlation Coefficient (r). The results of these performance measures were acceptable and reliable. The Regression model had Mean Absolute Percentage Error (MAPE) of 2.98% for the test sets, which is a very small and acceptable amount of error for a model.

5.2. Recommendations

1. Contractors are advised to give serious attention for the factors listed out in this paper as they have a great impact in affecting construction performance. They should be careful in selecting and allocating their resources since performance relies majorly on the resource availability and quality.
2. This model was developed under the assumption that client is financially capable to fund the projects and adequate resources are available to some degree. Financial capability and resource availability of the client is a very important factor that shouldn't be ignored because, if there is no timely payment paid to the contractor, there would not be any performance to measure. So, before using the developed model one should first check whether these major requirements are met.
3. Contractors should be more interested with conformance to project specification to overcome disputes, time and cost performance problems. Contractors should be more interested with quality materials to improve cost, time and quality performance and Contractors are recommended to give more attention with sequencing of work according to schedule.
4. All managerial levels should participate with sensitive and important decision-making. Continuous coordination and relationship between project participants are required through project life cycle in order to solve problems and develop project performance and it is recommended to minimize disputes between owner and project parties
5. Special attention should be given by the consultants on the issues related to Delay in Decision making, Incomplete and Inaccurate drawings, Inspection and Instruction delay, and Change of work order/Variation in order to minimize their impacts on affecting performance of road construction projects.

5.3. Recommendations for Future Research

1. The current research study was limited to the road construction industry in the region in Ethiopia. Future study could be done in other parts of Ethiopia and could emphasize specific types of road constructions like expressways.
2. Since this research was limited only in modeling construction performance of road construction in general, the researcher strongly recommends that different models for different factors should be done separately like Time performance, Cost Performance, Quality performance, productivity Performance, etc.
3. A study similar to the present research is needed for Building projects to find factors that affect the performance of building construction projects, which will help departments of Building to minimize unnecessary cost escalations and project-schedule delays.

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Appendix 1

Bahir Dar University

Bahir Dar Institute of Technology

School of Research and Graduate Studies

Faculty of Civil and Water Resource Engineering

MSc Program in Construction Technology and Management

Dear respondents,

The objective of this questionnaire is to identify and assess the critical factors that affect the performance of road construction projects in Ethiopia.

This questionnaire is prepared for data collection of a Research on **Development of a Predictive Regression Model for Estimating Construction Performance of Ethiopian Federal Road Projects**.

Part one: personal data

1.1. Academic background ______________________________

1.2. Job Title/Position

☐ Project Manager ☐ Site Engineer ☐ Office Engineer

☐ Others (Specify) ______________________________

1.3. Work experience in the sector (in years)

☐ Less than 5 ☐ 5 – 10 ☐ 10 - 15 ☐ Greater than 15

Part two: Company background information

2.1. Organization you are working for

☐ Client ☐ Consultant ☐ Contractor

2.2. Working experience **of the company** in the Road sector (in years)

☐ Less than 5 ☐ 5 – 10 ☐ 10 - 15 ☐ Greater than 15

Part Three: Performance Related Problems in Federal road Construction Projects

Below are numbers of performance related problems in federal road construction projects. From your experience, please express your opinion on rate of occurrences in road construction projects in Ethiopia based on the representative numbers listed below. (Please tick the appropriate box).

1= Never, 2= Sometimes, 3= Usually, 4= Frequently and 5= Most Frequently.

No.	Performance Problem	Rate Of Occurrence				
		1	2	3	4	5
1	Cost					
2	Time					
3	Quality					
4	Productivity					
5	Client Satisfaction					
6	Health and safety					
7	Innovation and Learning					

Part Four: Key Performance Indicators' Expressway Construction Projects

Based on the occurrence of performance related problems you filled under part three, below are numbers of key performance indicators' of federal road construction projects. From your experience, please fill the effect of these occurrences on project performance to determine the key performance indicators of road construction projects in Ethiopia on the following rating numbers. (Please tick the appropriate box).

1=Very Low, 2=Low, 3=Medium, 4=High, 5=Very High

No.	Key Performance Indicators (KPI)	1	2	3	4	5
1	Cost					
2	Time					
3	Quality					
4	Productivity					
5	Client Satisfaction					
6	Health and safety					
7	Innovation and Learning					

Part Five: Factors Affecting the Performance of road Construction Projects

Below are numbers of factors affecting the performance of construction projects. From your experience, please express your opinion on the impact of the following as factors that affecting performance of road construction projects in Ethiopia based on the associated numbers given here. (Please tick the appropriate box).

1=Very Low Impact, 2= Low Impact, 3= Medium, 4=High Impact, 5=Very High

(1) Cost factors	1	2	3	4	5

Market share of organization					
Cash flow of project					
Profit rate of project					
Material and equipment cost					
Project labour cost					
Project overtime cost					
Cost of rework					
Cost of variation orders					
Waste rate of materials					
Escalation of material prices					
Differentiation of currency prices					
Incomplete drawing					
If any other, please specify					

(2) Time factors	**1**	**2**	**3**	**4**	**5**
Too many change orders from owner					
Poor project management assistance					
Unforeseen ground conditions					
Low speed of decision making					
Project complexity					
Effective communication					
Financial constraints					
Average delay in claim approval					
Average delay in payments from owners to contractors					
Site preparation time					
Unavailability of resources					
Time needed to rectify defects					
Time needed to implement variation orders					
If any other, please specify					

(3) Quality factors	**1**	**2**	**3**	**4**	**5**
Conformance to specification					

Unavailability of competent staff					
Quality of equipment or machineries and raw materials					
Quality assessment system in organization					
Quality training or meeting					
Incomplete drawing					
Incomplete technical specification					
If any other, please specify					

(4) Productivity factors	1	2	3	4	5
Project size and complexity					
Management-labour relationship					
Absenteeism rate through project (late start and early exists)					
Number of new projects per year					
Sequencing of work according to schedule					
Local cultural characteristics					
Non-working holidays					
Local climate conditions					
Employees motivation					
Employees attitudes					
If any other, please specify					

(5) Client Satisfaction factors	1	2	3	4	5
Leadership skills for project manager					
Number of disputes between owner and project parties					
Speed and reliability of service to owner					
Number of rework incidents					
Information coordination between owner and project parties					
Conflict					
Poor workmanship and incompetence workers					

If any other, please specify					

(6)Health and Safety	1	2	3	4	5
Reportable accidents rate in project					
Application of health and safety factors in organization					
Assurance rate of project					
Easiness to reach to the site (location of project).					
Wastes around the site					
Climate condition and Air quality					
Noise level					
If any other, please specify					

(7) Innovation and Learning	1	2	3	4	5
Learning from own experience and past history					
Learning from best practice and experience of others					
Review of failures and solving them					
Work group					
Training the human resources in the skills demanded by the project					
If any other, please specify					

Appendix 2

Questionnaire 2

Title of Research: "Development of a Predictive Regression Model for Estimating Construction Performance of Ethiopian Federal Road Projects"

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Faculty of Civil and Water Resource Engineering

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July 2022

All information in the questionnaire will be used for research with complete commitment for absolute secrecy to your information. Please identify the value of factors that have an impact on productivity of block work in your project.

1. Project name: ____
2. Project location: ____
3. Project Length (in Km):_____________________________________
4. Working hour per day:_______________________________________

5. Overall **Performance of the Project** (Based on ERA's Valuation of Project Performance Up to June 2022): ________________
6. Average Percentage of **Material Price Escalation** Comparing current time to the Start of the project:________________
7. Percentage of **Material and Equipment Cost** to the revenue Collected to date:_____
8. Average **Delay in payments from Owner to Contractors** in days:____
9. Occurrence of cash flow problems in the project
   - ☐ Never
   - ☐ Rarely
   - ☐ Sometimes
   - ☐ Frequently
   - ☐ Always
10. **Resource availability**
    - ☐ Low
    - ☐ Moderate
    - ☐ Highly Available
11. Availability of **Competent/Skilled Manpower**
    - ☐ Low
    - ☐ Moderate
    - ☐ Highly Available
12. Quality of **Construction Equipment's**
    - ☐ Low quality
    - ☐ Medium quality
    - ☐ High quality
13. **Sequencing and performing of activities** according to schedule practice in the project
    - ☐ Never

- Rarely
- Sometimes
- Frequently
- Always

14. Occurrence of **disputes b/n client and project parties**

- Never
- Rarely
- Sometimes
- Frequently
- Always

THANK YOU!!!

Appendix 3

Chi-square Distribution

Critical values of the Chi-square distribution with *d* degrees of freedom

Probability of exceeding the critical value

d	0.05	0.01	0.001	*d*	0.05	0.01	0.001
1	3.841	6.635	10.828	11	19.675	24.725	31.264
2	5.991	9.210	13.816	12	21.026	26.217	32.910
3	7.815	11.345	16.266	13	22.362	27.688	34.528
4	9.488	13.277	18.467	14	23.685	29.141	36.123
5	11.070	15.086	20.515	15	24.996	30.578	37.697
6	12.592	16.812	22.458	16	26.296	32.000	39.252
7	14.067	18.475	24.322	17	27.587	33.409	40.790
8	15.507	20.090	26.125	18	28.869	34.805	42.312
9	16.919	21.666	27.877	19	30.144	36.191	43.820
10	18.307	23.209	29.588	20	31.410	37.566	45.315

***INTRODUCTION TO POPULATION GENETICS*, Table D.1**